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**Minnelli et al.**

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(54) **SURGICAL ACCESS DEVICE**

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(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

477,639 A 6/1892 Brinkerhoff  
1,641,856 A 9/1927 Lloyd et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2060930 A1 10/1992  
CA 2661238 A1 10/2009

(Continued)

OTHER PUBLICATIONS

Extended European Search Report issued in European Application No. 12173272.1 dated Jul. 19, 2012.

(Continued)

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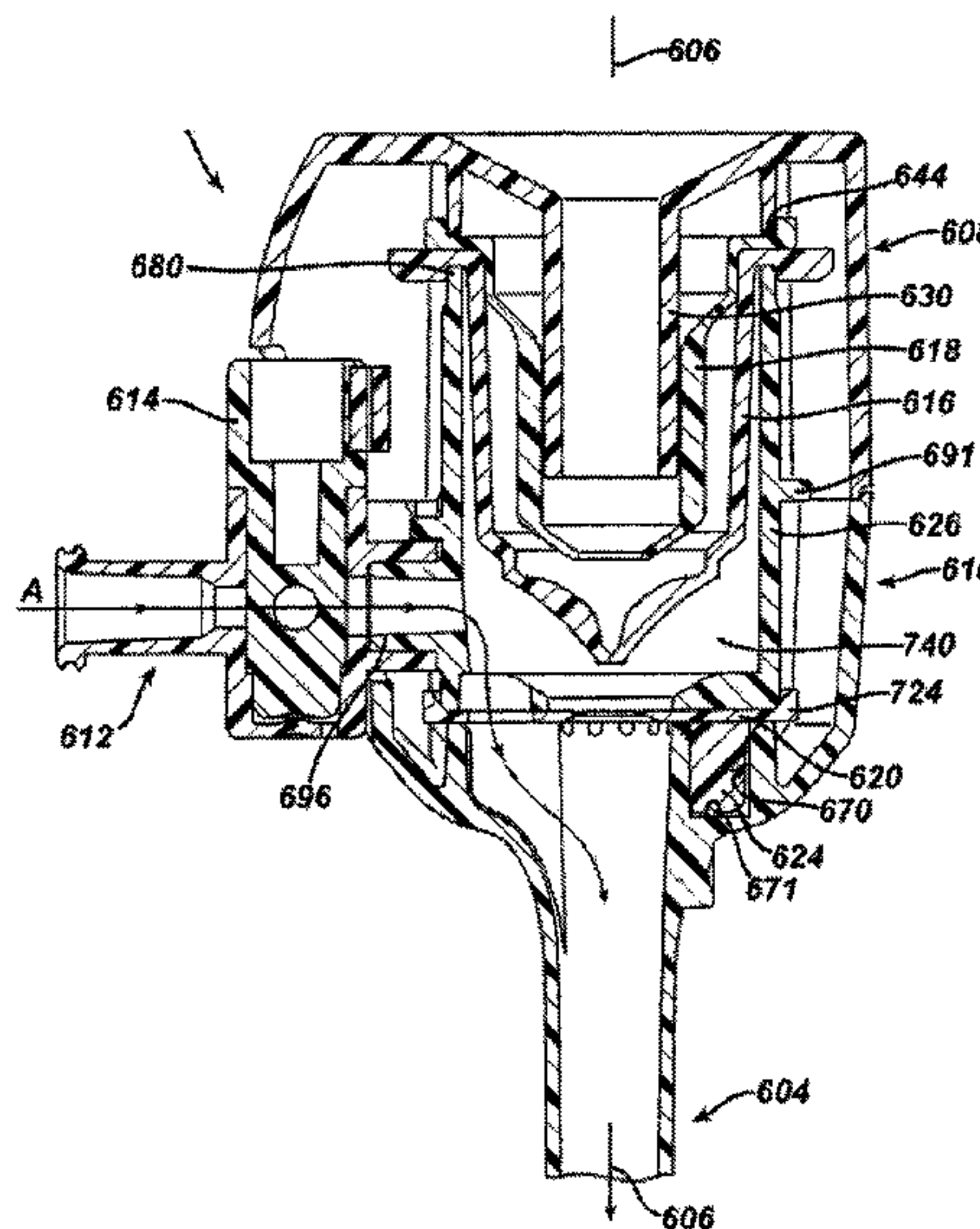
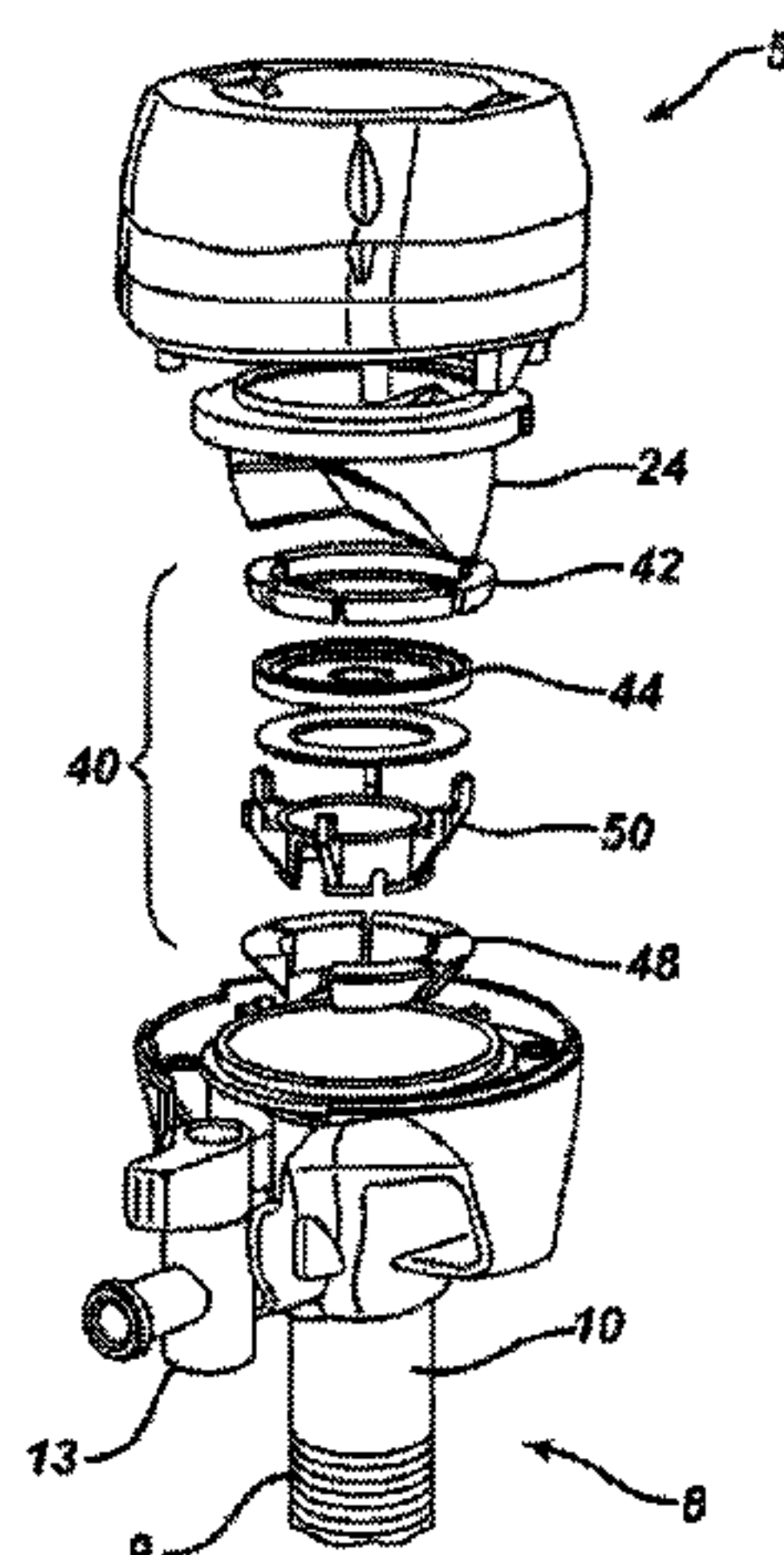
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(57) **ABSTRACT**

The present invention generally provides methods and devices for removing fluid from a surgical instrument. Surgical access devices and seal systems are generally provided having one or more valves or seal assemblies to create a closed system between the outside environment and the environment in which the surgical access device is being inserted. The devices of systems can also include a fluid remover in the form of a sorbent element, a scraper element, a wicking element, or any combination thereof that is configured to remove fluid from a working channel of the device or system and/or from a surgical instrument inserted therethrough.

**26 Claims, 48 Drawing Sheets**





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(58) **Field of Classification Search**

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(56)

**References Cited**

U.S. PATENT DOCUMENTS

1,775,403 A 9/1930 Maclean  
 2,628,404 A 2/1953 Myers  
 3,229,691 A 1/1966 Crowe, Jr.  
 3,566,871 A 3/1971 Richter et al.  
 3,900,022 A 8/1975 Widran  
 3,903,877 A 9/1975 Terada  
 3,924,608 A 12/1975 Mitsui  
 3,980,078 A 9/1976 Tominaga  
 3,981,276 A 9/1976 Ernest  
 4,204,563 A 5/1980 Pyle  
 4,279,246 A 7/1981 Chikama  
 4,281,646 A 8/1981 Kinoshita  
 4,335,721 A 6/1982 Matthews  
 4,352,527 A 10/1982 Sandstrom  
 4,363,357 A 12/1982 Hunter  
 4,453,838 A 6/1984 Loizeau  
 4,651,517 A 3/1987 Benhamou et al.  
 4,687,033 A 8/1987 Furrow et al.  
 4,690,140 A 9/1987 Mecca  
 4,722,000 A 1/1988 Chatenever  
 4,836,187 A 6/1989 Iwakoshi et al.  
 4,844,052 A 7/1989 Iwakoshi et al.  
 4,847,364 A 7/1989 Mockli  
 4,877,016 A 10/1989 Kantor et al.  
 4,919,305 A 4/1990 Podgers  
 4,929,235 A 5/1990 Merry et al.  
 4,934,135 A 6/1990 Rozenwasser  
 4,942,867 A 7/1990 Takahashi et al.  
 4,943,280 A 7/1990 Lander  
 4,958,970 A 9/1990 Rose et al.  
 4,960,412 A \* 10/1990 Fink ..... A61M 39/0606  
 604/167.04  
 5,000,745 A 3/1991 Guest et al.  
 5,013,199 A 5/1991 Downes  
 5,084,057 A 1/1992 Green et al.  
 5,104,383 A 4/1992 Shichman  
 5,112,308 A 5/1992 Olsen et al.

5,127,909 A 7/1992 Shichman  
 5,167,220 A 12/1992 Brown  
 5,180,373 A 1/1993 Green et al.  
 5,191,878 A 3/1993 Iida et al.  
 5,197,955 A 3/1993 Stephens et al.  
 5,201,714 A 4/1993 Gentelia et al.  
 5,207,213 A 5/1993 Auhll et al.  
 5,209,737 A 5/1993 Ritchart et al.  
 5,226,891 A 7/1993 Bushatz et al.  
 5,237,984 A 8/1993 Williams, III et al.  
 5,242,412 A 9/1993 Blake, III  
 5,256,149 A 10/1993 Banik et al.  
 5,274,874 A \* 1/1994 Cercone ..... A61B 1/122  
 15/118  
 5,279,542 A 1/1994 Wilk  
 5,308,336 A 5/1994 Hart et al.  
 5,312,351 A 5/1994 Gerrone  
 5,312,363 A 5/1994 Ryan et al.  
 5,312,397 A 5/1994 Cosmescu  
 5,313,934 A 5/1994 Wiita et al.  
 5,320,608 A 6/1994 Gerrone  
 5,320,610 A 6/1994 Yoon  
 5,326,013 A 7/1994 Green et al.  
 5,330,437 A 7/1994 Durman  
 5,334,164 A 8/1994 Guy et al.  
 5,337,730 A 8/1994 Maguire  
 5,339,800 A 8/1994 Wiita et al.  
 5,342,315 A 8/1994 Rowe et al.  
 5,347,988 A 9/1994 Hori  
 5,354,302 A 10/1994 Ko  
 5,364,002 A 11/1994 Green et al.  
 5,369,525 A 11/1994 Bala et al.  
 5,370,656 A 12/1994 Shevel  
 5,377,669 A 1/1995 Schulz  
 5,382,297 A 1/1995 Valentine et al.  
 5,386,817 A 2/1995 Jones  
 5,387,197 A 2/1995 Smith et al.  
 5,389,081 A 2/1995 Castro  
 5,391,154 A 2/1995 Young  
 5,392,766 A 2/1995 Masterson et al.  
 5,395,342 A 3/1995 Yoon  
 5,400,767 A 3/1995 Murdoch  
 5,407,433 A 4/1995 Loomas  
 5,419,309 A 5/1995 Biehl  
 5,419,311 A 5/1995 Yabe et al.  
 5,441,513 A 8/1995 Roth  
 5,443,452 A 8/1995 Hart et al.  
 5,448,990 A 9/1995 De Faria-Correa  
 5,449,370 A 9/1995 Vaitekunas  
 5,458,633 A 10/1995 Bailey  
 5,458,640 A 10/1995 Gerrone  
 5,462,100 A 10/1995 Covert et al.  
 5,464,008 A 11/1995 Kim  
 5,476,475 A 12/1995 Gadberry  
 5,486,154 A 1/1996 Kelleher  
 5,492,304 A 2/1996 Smith et al.  
 5,496,142 A 3/1996 Fodor et al.  
 5,496,280 A 3/1996 Vandenbroek et al.  
 5,496,345 A 3/1996 Kieturakis et al.  
 5,496,411 A 3/1996 Candy  
 5,514,084 A 5/1996 Fisher  
 5,514,153 A 5/1996 Bonutti  
 5,518,026 A 5/1996 Benjey  
 5,518,502 A 5/1996 Kaplan et al.  
 5,522,833 A 6/1996 Stephens et al.  
 5,533,496 A 7/1996 De Faria-Correa et al.  
 5,535,759 A 7/1996 Wilk  
 5,536,234 A 7/1996 Newman  
 5,542,931 A 8/1996 Gravener et al.  
 5,545,142 A 8/1996 Stephens et al.  
 5,545,179 A 8/1996 Williamson, IV  
 5,549,543 A 8/1996 Kim  
 5,551,448 A 9/1996 Matula et al.  
 5,554,151 A 9/1996 Hinchliffe  
 5,568,828 A 10/1996 Harris  
 5,569,183 A 10/1996 Kieturakis  
 5,569,205 A 10/1996 Hart et al.  
 5,575,756 A 11/1996 Karasawa et al.  
 5,584,850 A 12/1996 Hart et al.



(56)

## References Cited

## U.S. PATENT DOCUMENTS

5,590,697	A	1/1997	Benjey et al.	6,217,509	B1	4/2001	Foley et al.
5,591,192	A	1/1997	Privitera et al.	6,253,802	B1	7/2001	Enge
5,603,702	A	2/1997	Smith et al.	6,258,025	B1	7/2001	Swallert
5,605,175	A	2/1997	Bergsma et al.	6,258,065	B1	7/2001	Dennis et al.
5,628,732	A	5/1997	Antoon, Jr. et al.	6,264,604	B1	7/2001	Kieturakis et al.
5,630,795	A	5/1997	Kuramoto et al.	6,287,313	B1	9/2001	Sasso
5,630,813	A	5/1997	Kieturakis	6,354,992	B1	3/2002	Kato
5,634,911	A	6/1997	Hermann et al.	6,371,909	B1	4/2002	Hoeg et al.
5,643,227	A	7/1997	Stevens	6,409,657	B1	6/2002	Kawano
5,643,301	A	7/1997	Mollenauer	6,423,266	B1	7/2002	Choperena et al.
5,647,372	A	7/1997	Tovey et al.	6,425,535	B1	7/2002	Akiba
5,647,840	A	7/1997	D'Amelio et al.	6,425,859	B1	7/2002	Foley et al.
5,651,757	A	7/1997	Meckstroth	6,443,190	B1	9/2002	Enge
5,658,273	A	8/1997	Long	6,447,446	B1	9/2002	Smith et al.
5,662,614	A	9/1997	Edoga	6,482,181	B1	11/2002	Racenet et al.
5,685,823	A	11/1997	Ito et al.	6,494,893	B2	12/2002	Dubrul et al.
5,688,222	A	11/1997	Hluchy et al.	6,497,687	B1	12/2002	Blanco
5,709,664	A	1/1998	Vandenbroek et al.	6,516,835	B2	2/2003	Enge
5,720,756	A	2/1998	Green et al.	6,517,246	B2	2/2003	Blakley
5,720,759	A	2/1998	Green et al.	6,520,907	B1	2/2003	Foley et al.
5,725,477	A	3/1998	Yasui et al.	6,534,002	B1	3/2003	Lin et al.
5,725,478	A	3/1998	Saad	6,551,282	B1	4/2003	Exline et al.
5,743,884	A	4/1998	Hasson et al.	6,562,046	B2	5/2003	Sasso
5,752,938	A	5/1998	Flatland et al.	6,569,120	B1	5/2003	Green et al.
5,755,252	A	5/1998	Bergsma et al.	6,595,915	B2	7/2003	Akiba
5,755,732	A	5/1998	Green et al.	6,595,946	B1	7/2003	Pasqualucci
5,776,112	A	7/1998	Stephens et al.	6,601,617	B2	8/2003	Enge
5,782,751	A	7/1998	Matsuno	6,605,098	B2	8/2003	Nobis et al.
5,782,859	A	7/1998	Nicholas et al.	6,638,214	B2	10/2003	Akiba
5,788,676	A	8/1998	Yoon	6,648,906	B2	11/2003	Lasheras et al.
5,792,044	A	8/1998	Foley et al.	6,668,418	B2	12/2003	Bastien
5,792,113	A	8/1998	Kramer et al.	6,679,833	B2	1/2004	Smith et al.
5,797,434	A	8/1998	Benjey et al.	6,679,834	B2	1/2004	Stahl et al.
5,807,338	A	9/1998	Smith et al.	6,679,837	B2	1/2004	Daikuzono
5,814,026	A	9/1998	Yoon	6,685,665	B2	2/2004	Booth et al.
D399,316	S	10/1998	Molina	6,699,185	B2	3/2004	Gminder et al.
5,817,061	A	10/1998	Goodwin et al.	6,702,787	B2	3/2004	Pasqualucci et al.
5,820,600	A	10/1998	Carlson et al.	6,712,757	B2	3/2004	Becker et al.
5,842,971	A	12/1998	Yoon	6,726,663	B1	4/2004	Dennis
5,848,992	A	12/1998	Hart et al.	6,755,782	B2	6/2004	Ogawa
5,860,458	A	1/1999	Benjey et al.	6,860,869	B2	3/2005	Dennis
5,871,440	A	2/1999	Okada	6,860,892	B1	3/2005	Tanaka et al.
5,882,345	A	3/1999	Yoon	6,873,409	B1	3/2005	Slater
5,895,377	A	4/1999	Smith et al.	6,916,286	B2	7/2005	Kazakevich
5,902,231	A	5/1999	Foley et al.	6,918,924	B2	7/2005	Lasheras et al.
5,902,264	A	5/1999	Toso et al.	6,923,759	B2	8/2005	Kasahara et al.
5,906,595	A	5/1999	Powell et al.	6,942,671	B1	9/2005	Smith
5,906,598	A	5/1999	Giesler et al.	6,976,957	B1	12/2005	Chin et al.
5,944,654	A	8/1999	Crawford	6,981,966	B2	1/2006	Green et al.
5,954,635	A	9/1999	Foley et al.	6,989,003	B2	1/2006	Wing et al.
5,957,888	A	9/1999	Hinchliffe	7,008,416	B2	3/2006	Sakaguchi et al.
5,961,505	A	10/1999	Coe et al.	7,025,747	B2	4/2006	Smith
5,964,781	A	10/1999	Mollenauer et al.	7,052,454	B2	5/2006	Taylor
5,983,958	A	11/1999	Bergsma et al.	7,056,303	B2	6/2006	Dennis et al.
5,989,183	A	11/1999	Reisdorf et al.	7,056,321	B2	6/2006	Pagliuca et al.
5,989,224	A	11/1999	Exline et al.	7,060,025	B2	6/2006	Long et al.
5,993,380	A	11/1999	Yabe et al.	7,077,803	B2	7/2006	Kasahara et al.
6,004,326	A	12/1999	Castro et al.	7,083,626	B2	8/2006	Hart et al.
6,007,487	A	12/1999	Foley et al.	7,104,657	B2	9/2006	Sherwin
6,017,333	A	1/2000	Bailey	7,105,009	B2	9/2006	Johnson et al.
D425,619	S	5/2000	Bierman	7,112,185	B2	9/2006	Hart et al.
6,062,276	A	5/2000	Benjey et al.	7,163,525	B2	1/2007	Fraser
6,063,050	A	5/2000	Manna et al.	7,169,130	B2	1/2007	Exline et al.
6,110,103	A	8/2000	Donofrio	D541,417	S	4/2007	Albrecht et al.
6,126,592	A	10/2000	Proch et al.	7,198,598	B2	4/2007	Smith et al.
6,152,871	A	11/2000	Foley et al.	7,207,347	B2	4/2007	Olshanetsky et al.
6,159,182	A	12/2000	Davis et al.	7,244,244	B2	7/2007	Racenet et al.
6,162,170	A	12/2000	Foley et al.	D555,788	S	11/2007	Southwell et al.
6,167,920	B1	1/2001	Enge	7,309,469	B2	12/2007	Anderson et al.
6,176,823	B1	1/2001	Foley et al.	D559,080	S	1/2008	Boote
6,176,825	B1	1/2001	Chin et al.	7,344,519	B2	3/2008	Wing et al.
6,206,057	B1	3/2001	Benjey et al.	D567,372	S	4/2008	Chesnin
6,206,822	B1	3/2001	Foley et al.	7,371,227	B2	5/2008	Zeiner
6,209,306	B1	4/2001	Chia et al.	D573,255	S	7/2008	Stephens
6,216,661	B1	4/2001	Pickens et al.	7,444,801	B2	11/2008	Rosenwasser et al.
				7,473,243	B2	1/2009	Dennis et al.
				D589,617	S	3/2009	Carter
				7,507,210	B2	3/2009	Hibner et al.
				7,591,802	B2	9/2009	Johnson et al.



(56)

References Cited

U.S. PATENT DOCUMENTS

7,717,412 B2 5/2010 Anzai  
 7,785,294 B2 8/2010 Hueil et al.  
 7,981,092 B2 7/2011 Duke  
 8,075,528 B2 12/2011 Widenhouse et al.  
 8,079,986 B2\* 12/2011 Taylor ..... A61B 17/3462  
 604/167.06  
 D652,509 S 1/2012 Kyvik et al.  
 8,147,481 B2 4/2012 Whittaker et al.  
 8,206,357 B2 6/2012 Bettuchi  
 8,206,376 B2 6/2012 Barron et al.  
 8,273,060 B2 9/2012 Moreno, Jr. et al.  
 8,328,768 B2 12/2012 Quigley et al.  
 8,551,058 B2 10/2013 Measamer et al.  
 8,568,362 B2 10/2013 Moreno, Jr. et al.  
 8,579,807 B2 11/2013 Moreno, Jr. et al.  
 8,636,686 B2 1/2014 Minnelli et al.  
 2002/0022762 A1\* 2/2002 Beane ..... A61B 1/122  
 600/101  
 2002/0035828 A1 3/2002 Chia et al.  
 2002/0065450 A1 5/2002 Ogawa  
 2002/0068923 A1 6/2002 Caldwell et al.  
 2002/0103420 A1 8/2002 Coleman et al.  
 2002/0107484 A1 8/2002 Dennis et al.  
 2002/0161387 A1 10/2002 Blanco  
 2003/0004529 A1 1/2003 Tsonton et al.  
 2003/0060770 A1 3/2003 Wing et al.  
 2003/0130674 A1 7/2003 Kasahara et al.  
 2003/0135942 A1 7/2003 Bastien  
 2003/0139756 A1 7/2003 Brustad  
 2003/0195472 A1 10/2003 Green et al.  
 2003/0208104 A1 11/2003 Carrillo et al.  
 2004/0034339 A1 2/2004 Stoller et al.  
 2004/0106942 A1 6/2004 Taylor et al.  
 2004/0167559 A1 8/2004 Taylor et al.  
 2004/0171990 A1 9/2004 Dennis et al.  
 2004/0220452 A1 11/2004 Shalman  
 2004/0230161 A1 11/2004 Zeiner  
 2004/0256004 A1 12/2004 Kessell et al.  
 2004/0260244 A1 12/2004 Piechowicz et al.  
 2005/0033342 A1 2/2005 Hart et al.  
 2005/0043683 A1 2/2005 Ravo  
 2005/0059865 A1 3/2005 Kahle et al.  
 2005/0059934 A1 3/2005 Wenchell et al.  
 2005/0070850 A1 3/2005 Albrecht  
 2005/0070946 A1 3/2005 Franer et al.  
 2005/0070947 A1 3/2005 Franer et al.  
 2005/0077688 A1 4/2005 Voegele et al.  
 2005/0077689 A1 4/2005 Hueil  
 2005/0096605 A1 5/2005 Green et al.  
 2005/0131349 A1 6/2005 Albrecht et al.  
 2005/0165277 A1 7/2005 Carrillo et al.  
 2005/0203543 A1 9/2005 Hilal et al.  
 2005/0216028 A1 9/2005 Hart et al.  
 2005/0222582 A1 10/2005 Wenchell  
 2005/0241647 A1 11/2005 Nguyen et al.  
 2005/0267419 A1 12/2005 Smith  
 2005/0288622 A1 12/2005 Albrecht et al.  
 2006/0020165 A1 1/2006 Adams  
 2006/0047240 A1 3/2006 Kumar et al.  
 2006/0052666 A1 3/2006 Kumar et al.  
 2006/0068360 A1 3/2006 Boulais  
 2006/0069306 A1 3/2006 Banik et al.  
 2006/0069312 A1 3/2006 O'Connor  
 2006/0100485 A1 5/2006 Arai et al.  
 2006/0122556 A1 6/2006 Kumar et al.  
 2006/0122557 A1 6/2006 Kumar et al.  
 2006/0129098 A1 6/2006 Hart et al.  
 2006/0135972 A1 6/2006 Zeiner  
 2006/0135977 A1 6/2006 Thompson et al.  
 2006/0135978 A1 6/2006 Franer  
 2006/0149137 A1 7/2006 Pingleton et al.  
 2006/0199998 A1 9/2006 Akui et al.  
 2006/0211916 A1 9/2006 Kasahara et al.  
 2006/0224121 A1 10/2006 Hart et al.  
 2006/0224164 A1 10/2006 Hart et al.

2006/0229565 A1 10/2006 Dennis et al.  
 2006/0235455 A1 10/2006 Oshida  
 2006/0264991 A1 11/2006 Johnson et al.  
 2006/0276688 A1 12/2006 Surti  
 2006/0293559 A1 12/2006 Grice et al.  
 2007/0005087 A1 1/2007 Smith et al.  
 2007/0021713 A1 1/2007 Kumar et al.  
 2007/0027453 A1 2/2007 Hart et al.  
 2007/0088275 A1 4/2007 Stearns et al.  
 2007/0088277 A1 4/2007 McGinley et al.  
 2007/0129719 A1 6/2007 Kendale et al.  
 2007/0142709 A1 6/2007 Martone et al.  
 2007/0149931 A1 6/2007 Cannon et al.  
 2007/0149993 A1 6/2007 Kasahara et al.  
 2007/0183867 A1 8/2007 Hesselmann et al.  
 2007/0185453 A1 8/2007 Michael et al.  
 2007/0191759 A1 8/2007 Stoller et al.  
 2007/0204890 A1 9/2007 Torii  
 2007/0225556 A1 9/2007 Ortiz et al.  
 2007/0225566 A1 9/2007 Kawanishi  
 2007/0244361 A1 10/2007 Ikeda et al.  
 2008/0009797 A1 1/2008 Stellon et al.  
 2008/0009832 A1 1/2008 Barron et al.  
 2008/0091143 A1 4/2008 Taylor et al.  
 2008/0249475 A1 10/2008 Albrecht et al.  
 2008/0269696 A1 10/2008 Exline et al.  
 2008/0275428 A1 11/2008 Tegg et al.  
 2008/0294113 A1 11/2008 Brockmeier et al.  
 2009/0005799 A1 1/2009 Franer et al.  
 2009/0030375 A1 1/2009 Franer et al.  
 2009/0093682 A1 4/2009 Izzo et al.  
 2009/0118586 A1\* 5/2009 Griffin ..... A61B 17/3421  
 600/204  
 2009/0137943 A1 5/2009 Stearns et al.  
 2009/0192444 A1 7/2009 Albrecht et al.  
 2009/0221960 A1 9/2009 Albrecht et al.  
 2009/0234293 A1 9/2009 Albrecht et al.  
 2009/0240204 A1 9/2009 Taylor et al.  
 2009/0264703 A1 10/2009 Pribanic  
 2009/0270681 A1 10/2009 Moreno et al.  
 2009/0270685 A1 10/2009 Moreno et al.  
 2009/0270813 A1 10/2009 Moreno, Jr. et al.  
 2009/0270817 A1 10/2009 Moreno et al.  
 2009/0281478 A1 11/2009 Duke  
 2009/0314422 A1 12/2009 Racenet et al.  
 2010/0022958 A1 1/2010 Moreno, Jr. et al.  
 2010/0185139 A1\* 7/2010 Stearns ..... A61B 17/3474  
 604/26  
 2010/0211049 A1 8/2010 Schertiger et al.  
 2010/0331822 A1 12/2010 Willemstyn  
 2011/0046449 A1 2/2011 Minnelli et al.  
 2011/0152775 A1 6/2011 Lopez et al.  
 2012/0140494 A1 6/2012 Gu et al.  
 2012/0330099 A1 12/2012 Moreno et al.

FOREIGN PATENT DOCUMENTS

DE 19619065 A1 11/1997  
 DE 10330518 A1 2/2005  
 EP 0517248 A1 12/1992  
 EP 0567142 A2 10/1993  
 EP 0568383 A1 11/1993  
 EP 0570802 A1 11/1993  
 EP 0664101 A1 7/1995  
 EP 0696459 A1 2/1996  
 EP 0731718 A1 9/1996  
 EP 0845960 A1 6/1998  
 EP 0875256 A1 11/1998  
 EP 0890342 A1 1/1999  
 EP 0898 71 A2 3/1999  
 EP 0972493 A2 1/2000  
 EP 1210904 A2 6/2002  
 EP 1284664 A1 2/2003  
 EP 1312318 A1 5/2003  
 EP 1323373 A2 7/2003  
 EP 1348386 A1 10/2003  
 EP 1459688 A1 9/2004  
 EP 1629787 A2 3/2006  
 EP 1679043 A1 7/2006

(56)

References Cited

FOREIGN PATENT DOCUMENTS

EP	1698291	A1	9/2006
EP	1707133	A1	10/2006
EP	1707135	A1	10/2006
EP	1709918	A1	10/2006
EP	1834571	A1	9/2007
EP	1834573	A1	9/2007
EP	1994895	A1	11/2008
GB	2298906	A	9/1996
JP	61-036718	A	2/1986
JP	03-106329	A	5/1991
JP	06-133927	A	5/1994
JP	06-169879	A	6/1994
JP	06-304121	A	11/1994
JP	07-178039		7/1995
JP	07-246187		9/1995
JP	07-289501	A	11/1995
JP	07-313442		12/1995
JP	08-154888		6/1996
JP	08-173372		7/1996
JP	08285001		11/1996
JP	10-043128		2/1998
JP	11-146882		6/1999
JP	2002-224014	A	8/2002
JP	2002-238906	A	8/2002
JP	2002282274	A	10/2002
JP	2003-284686	A	10/2003
JP	2004-016455	A	1/2004
JP	2004-267583	A	9/2004
JP	2005-253543	A	9/2005
JP	2005319101	A	11/2005
JP	2007117289	A	5/2007
JP	04-020324	B2	12/2007
JP	04-158825	B2	10/2008
JP	04-170929	B2	10/2008
JP	3151790	U	6/2009
JP	2009-189806	A	8/2009
JP	04-329510	B2	9/2009
JP	2009-261953	A	11/2009
JP	2009261923	A	11/2009
JP	05-192294	B2	5/2013

JP	05-199979	B2	5/2013
JP	05-207962	B2	6/2013
RU	2014032	C1	6/1994
WO	WO-9407552	A1	4/1994
WO	WO-9532019	A1	11/1995
WO	WO-9604946	A1	2/1996
WO	WO-9740759	A1	11/1997
WO	WO-9809673	A1	3/1998
WO	WO-01089371	A1	11/2001
WO	WO-02078527	A2	10/2002
WO	WO-02096307	A2	12/2002
WO	WO-03011154	A2	2/2003
WO	WO-2004043275	A1	5/2004
WO	WO-2005016133	A1	2/2005
WO	WO-2005030293	A2	4/2005
WO	WO-2005097019	A2	10/2005
WO	WO-2005097234	A2	10/2005
WO	WO-2008093313	A1	8/2008
WO	WO-2009005986	A1	1/2009

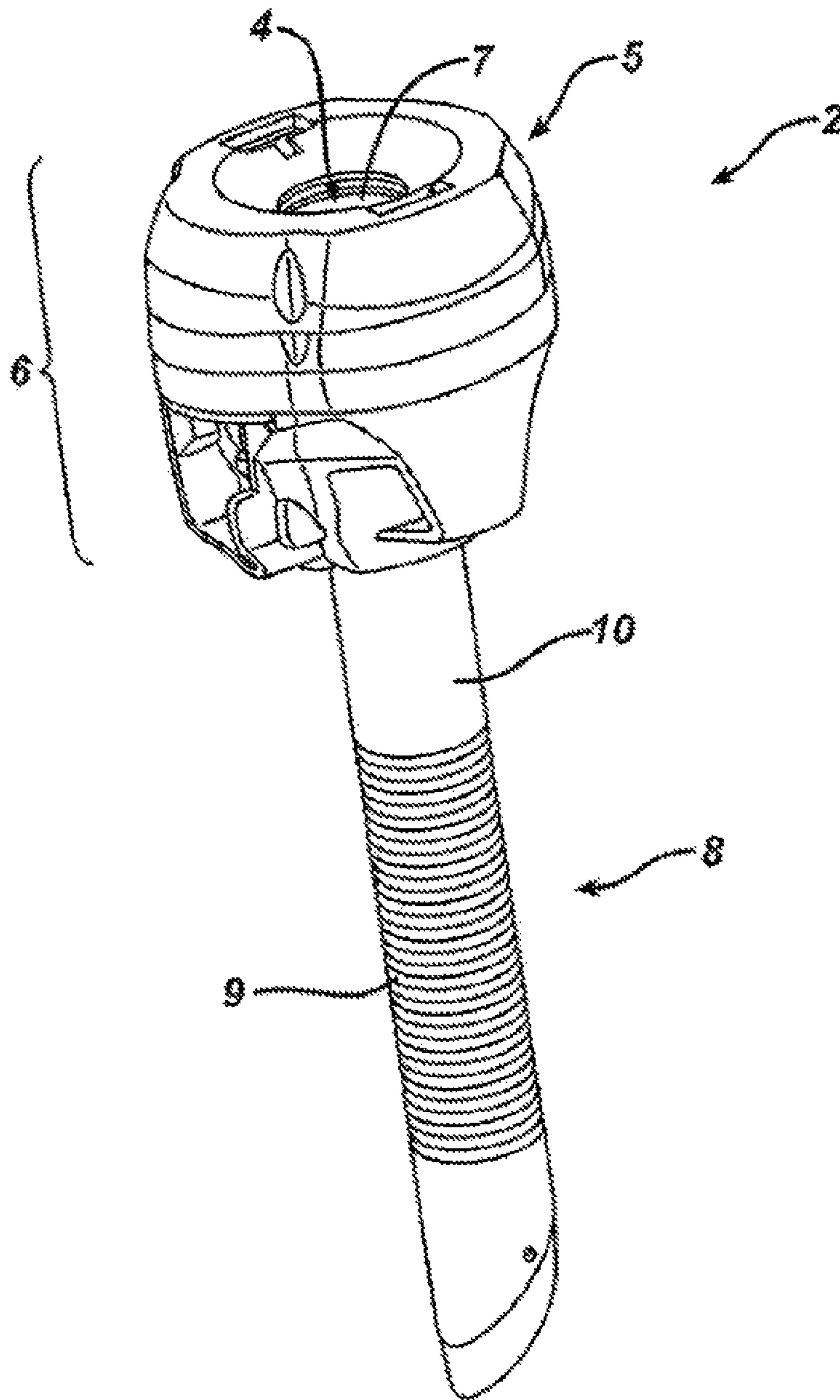
OTHER PUBLICATIONS

Extended European Search Report issued in European Application No. 12173277.0 dated Jul. 18, 2012.  
 Extended European Search Report issued in European Application No. 12173283.8 dated Jul. 18, 2012.  
 Extended European Search Report issued in European Application No. 12173290.3 dated Jul. 18, 2012.  
 International Search Report and Written Opinion issued in International Application No. PCT/US2010/042765 dated Oct. 13, 2010.  
 International Search Report and Written Opinion issued in International Application No. PCT/uS2010/055905 dated Jan. 11, 2012.  
 Search report issued in European Application No. 09251196.3 dated Aug. 11, 2009.  
 Search report issued in European Application No. 09251201.1 dated Aug. 13, 2009.  
 Search report issued in European Application No. 09251208.6 dated Aug. 11, 2009.  
 Search report issued in European Application No. 09251210.2 dated Aug. 12, 2009.

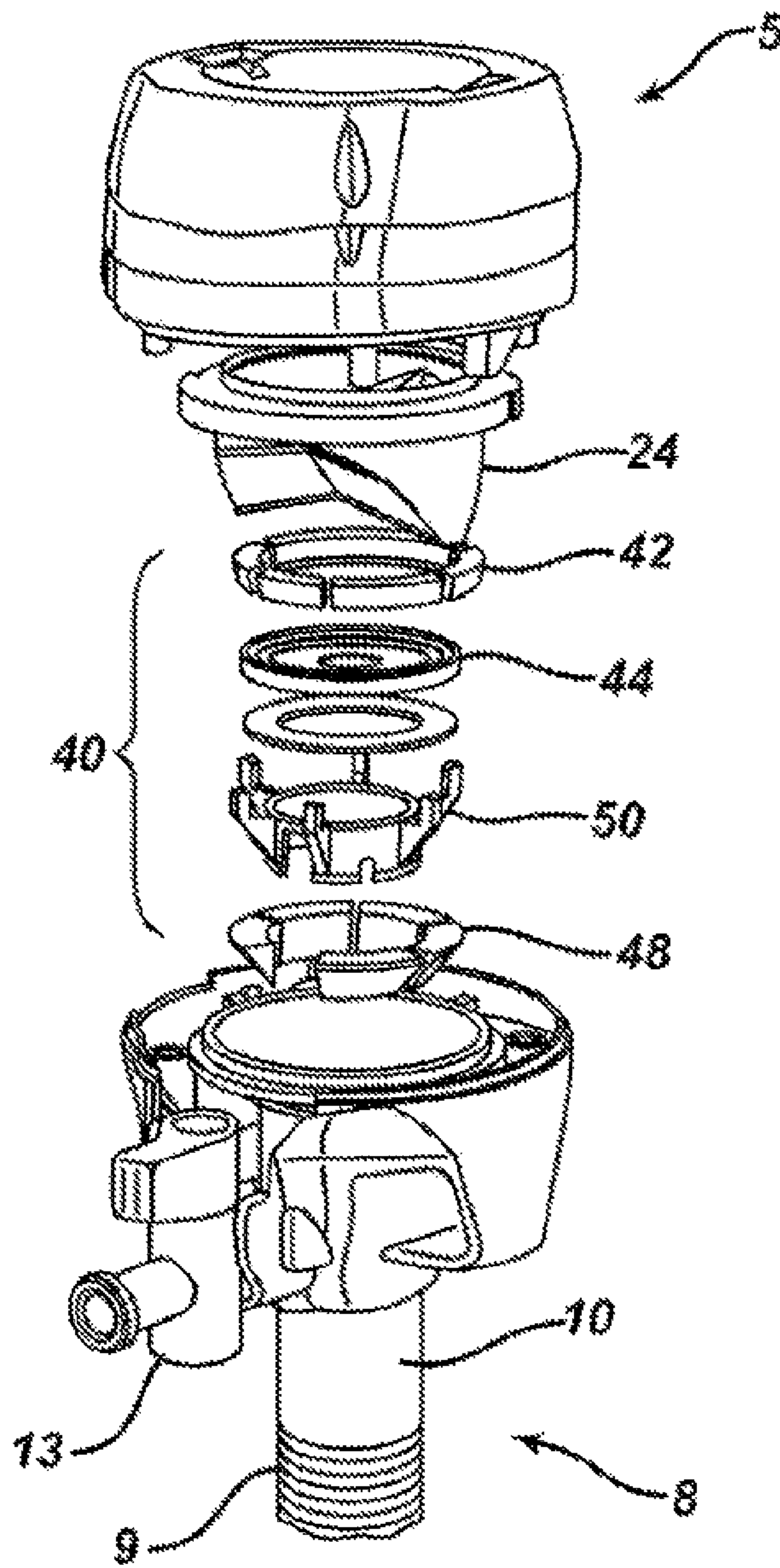
\* cited by examiner



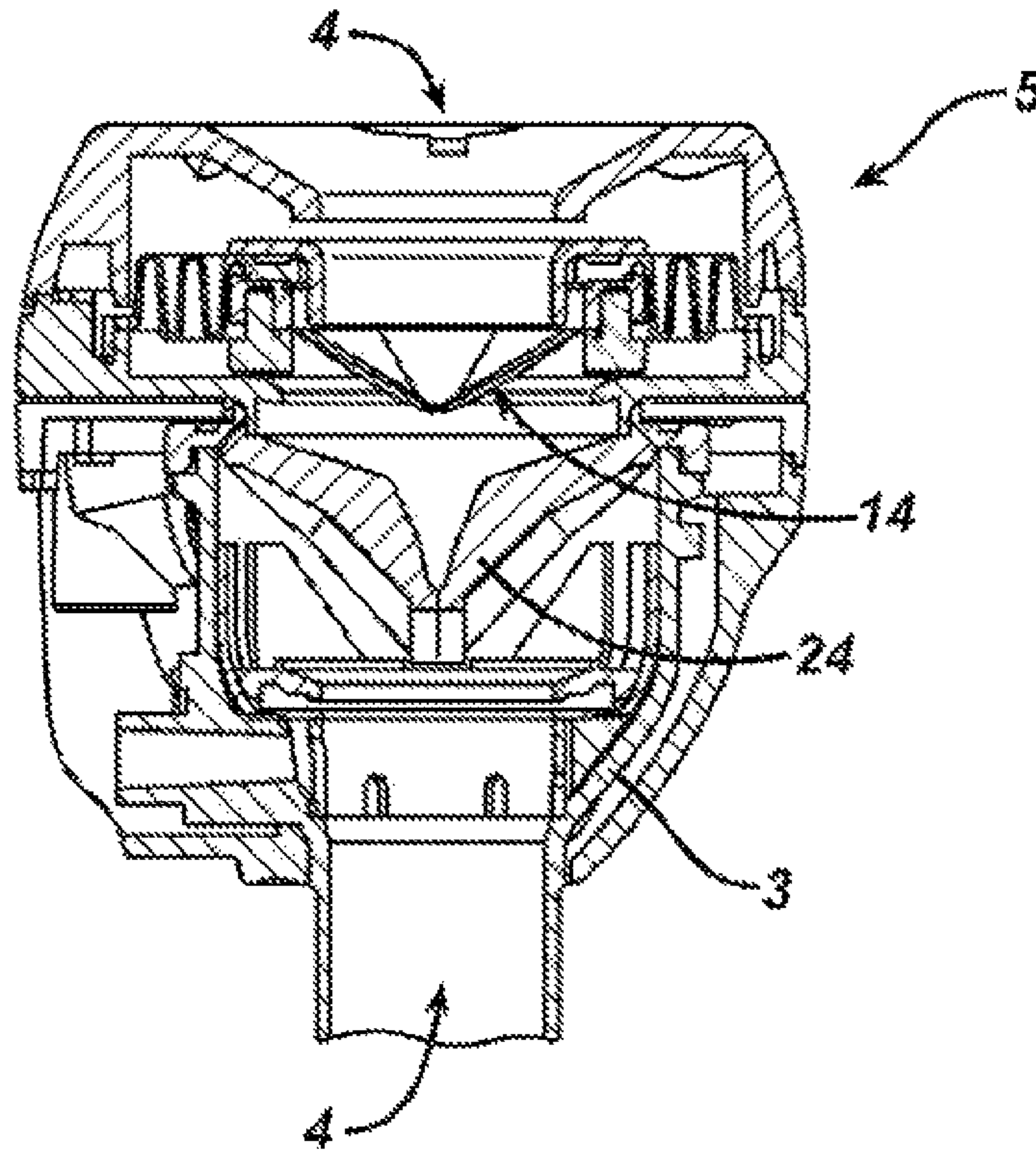
**FIG. 1A**



**FIG. 1B**



**FIG. 1C**



**FIG. 1D**

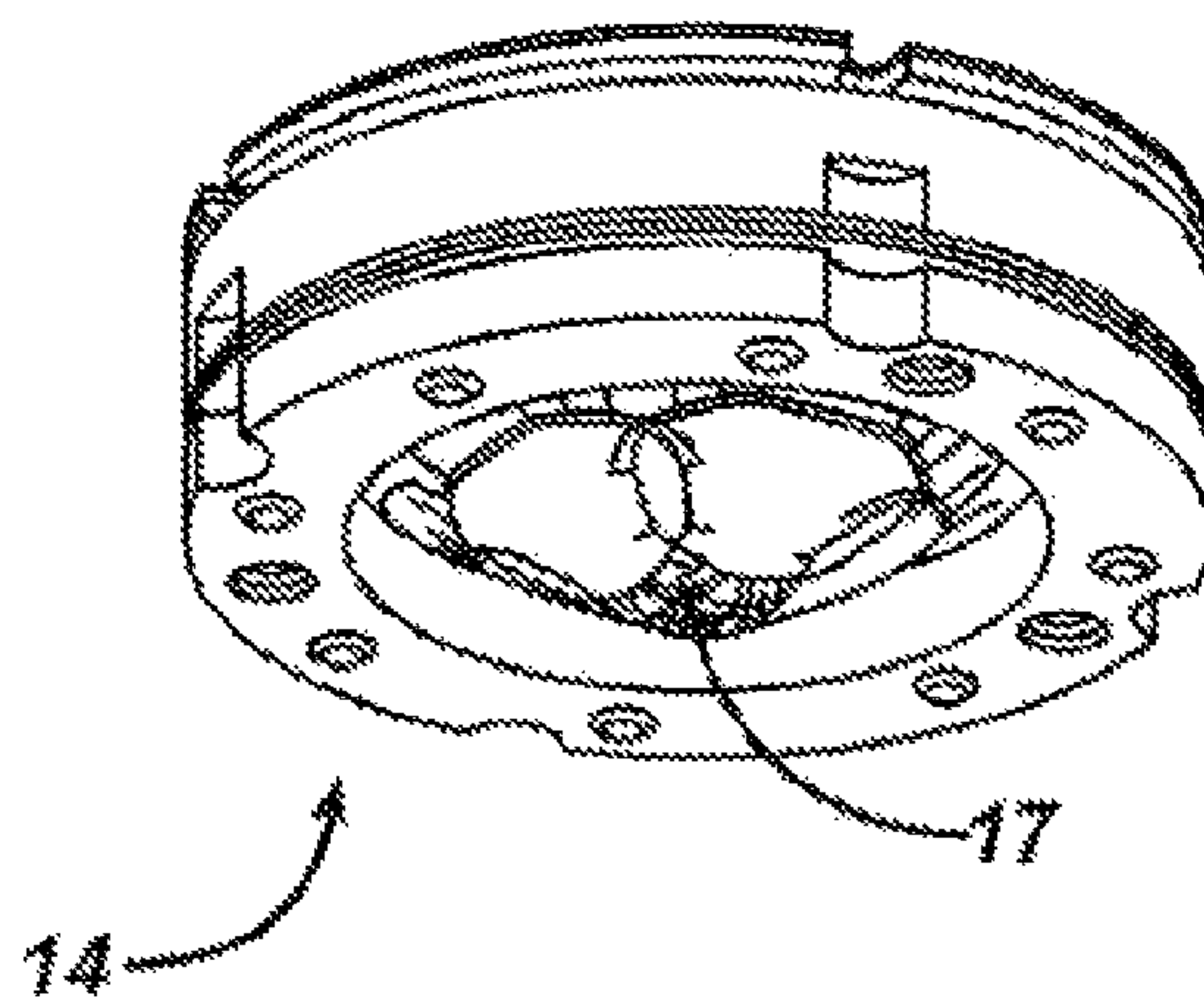
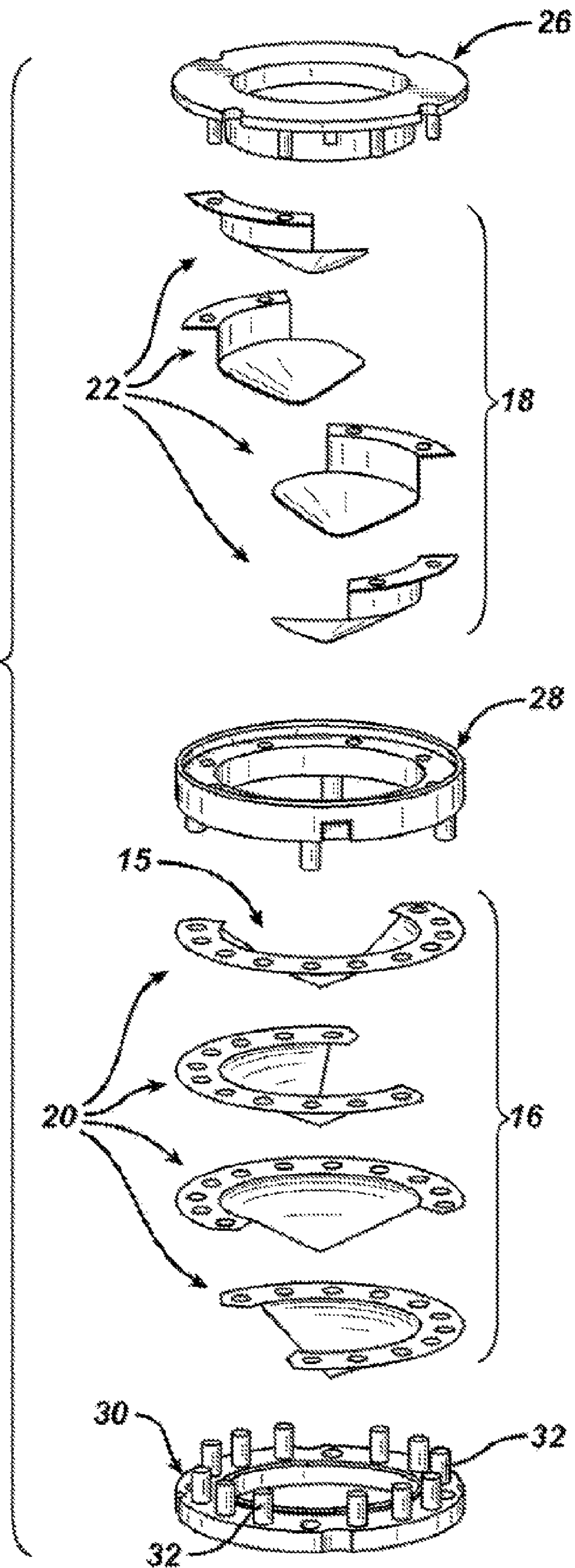
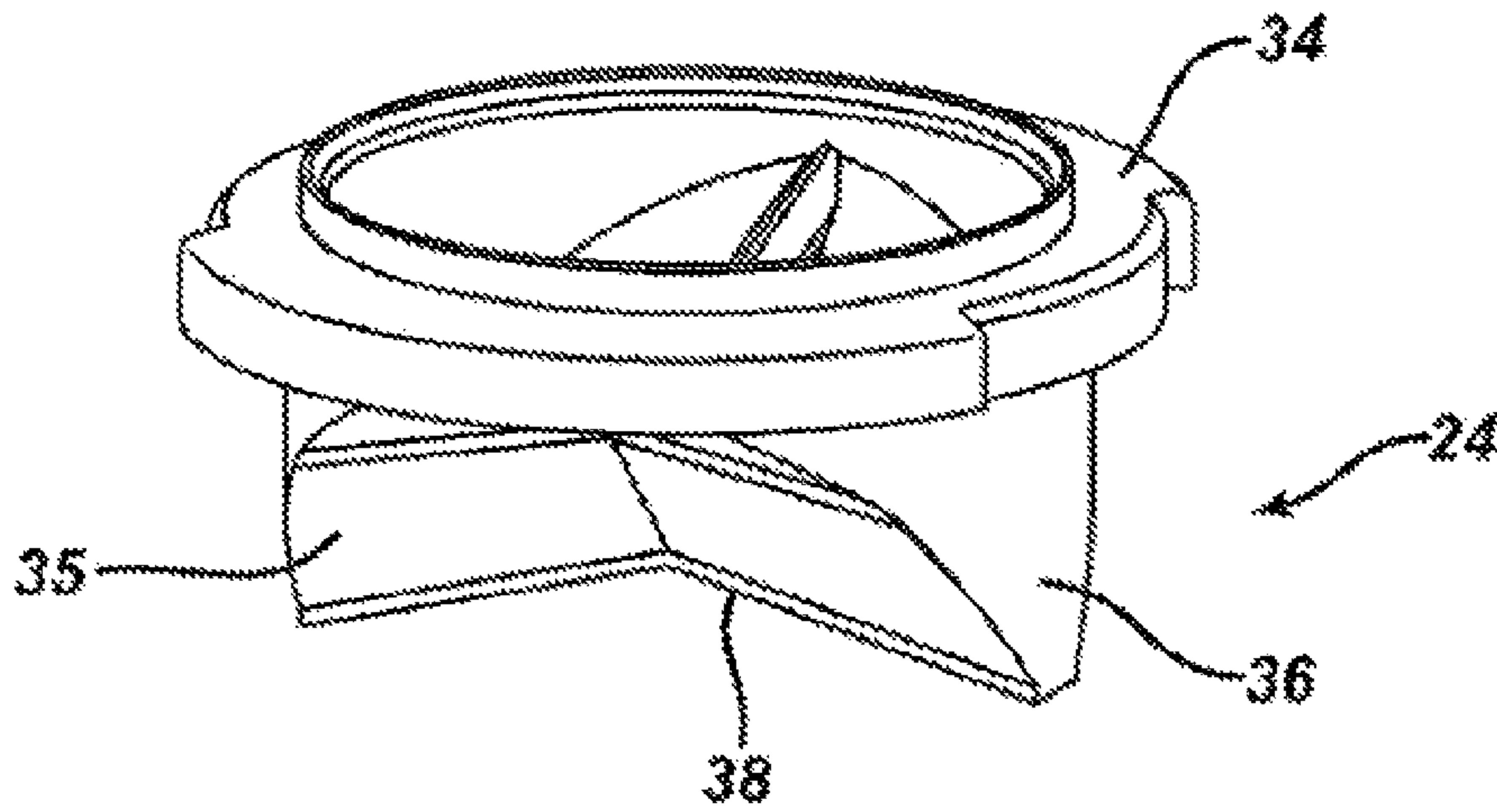




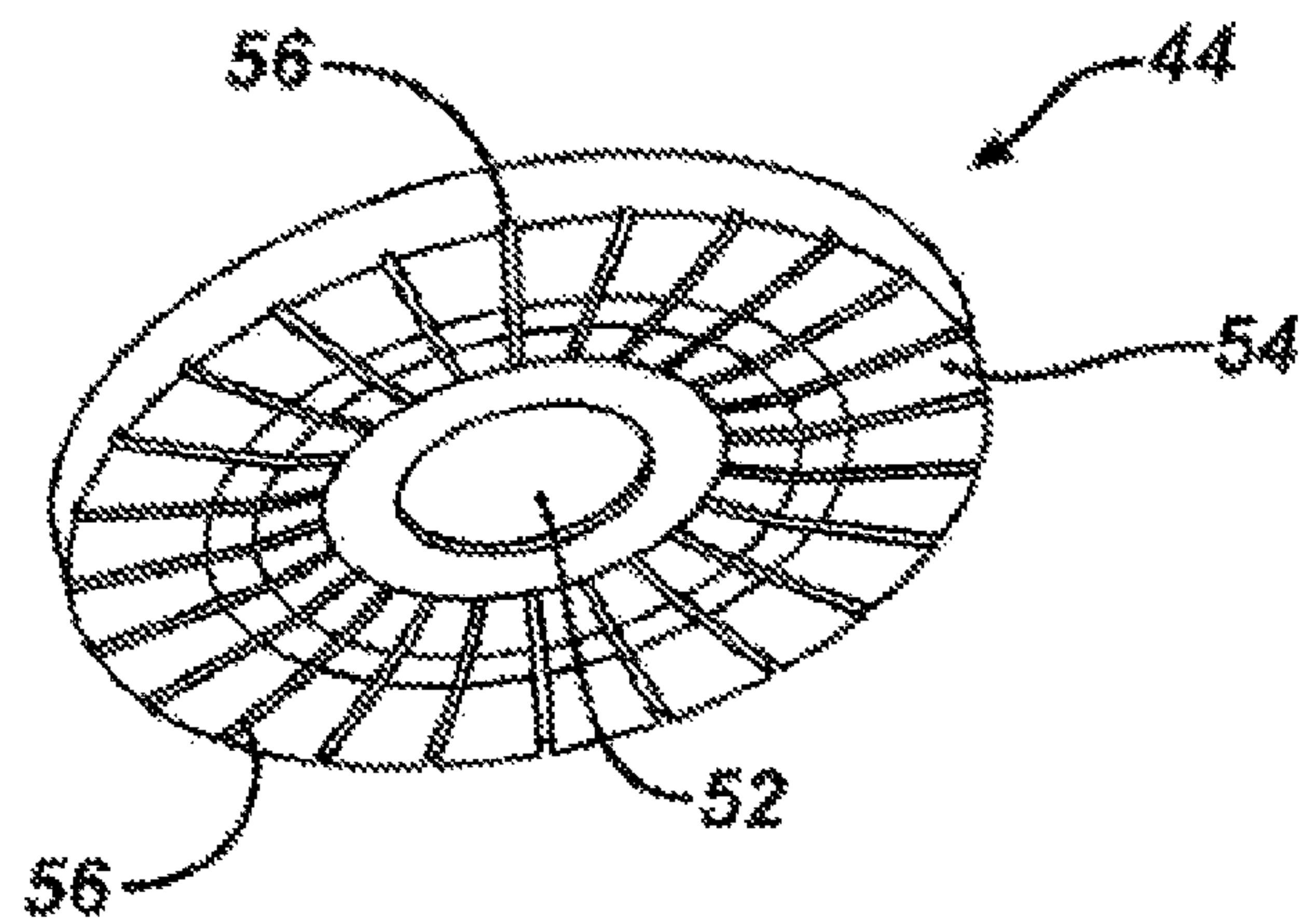
FIG. 1E



**FIG. 1F**

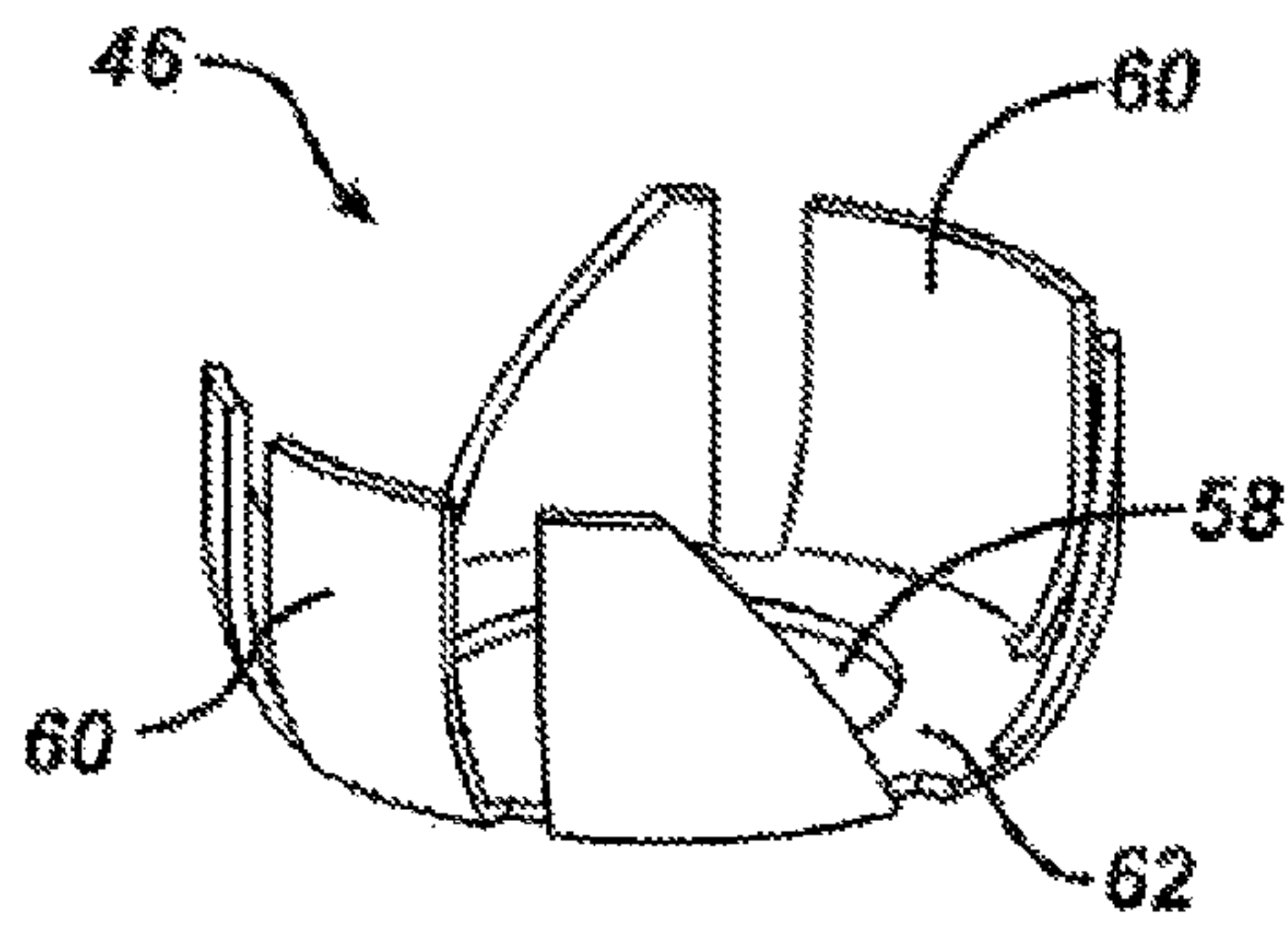


**FIG. 1G**

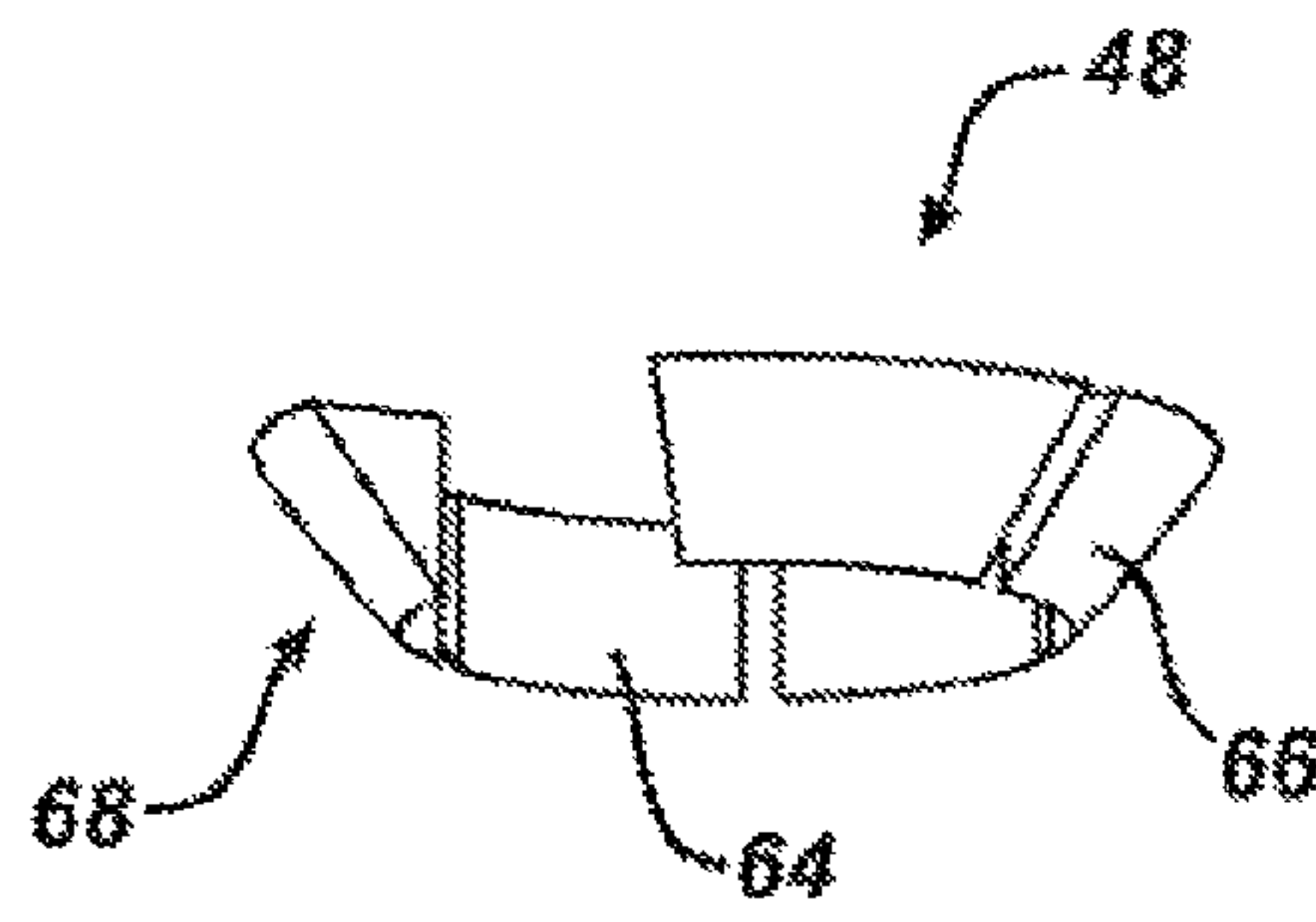




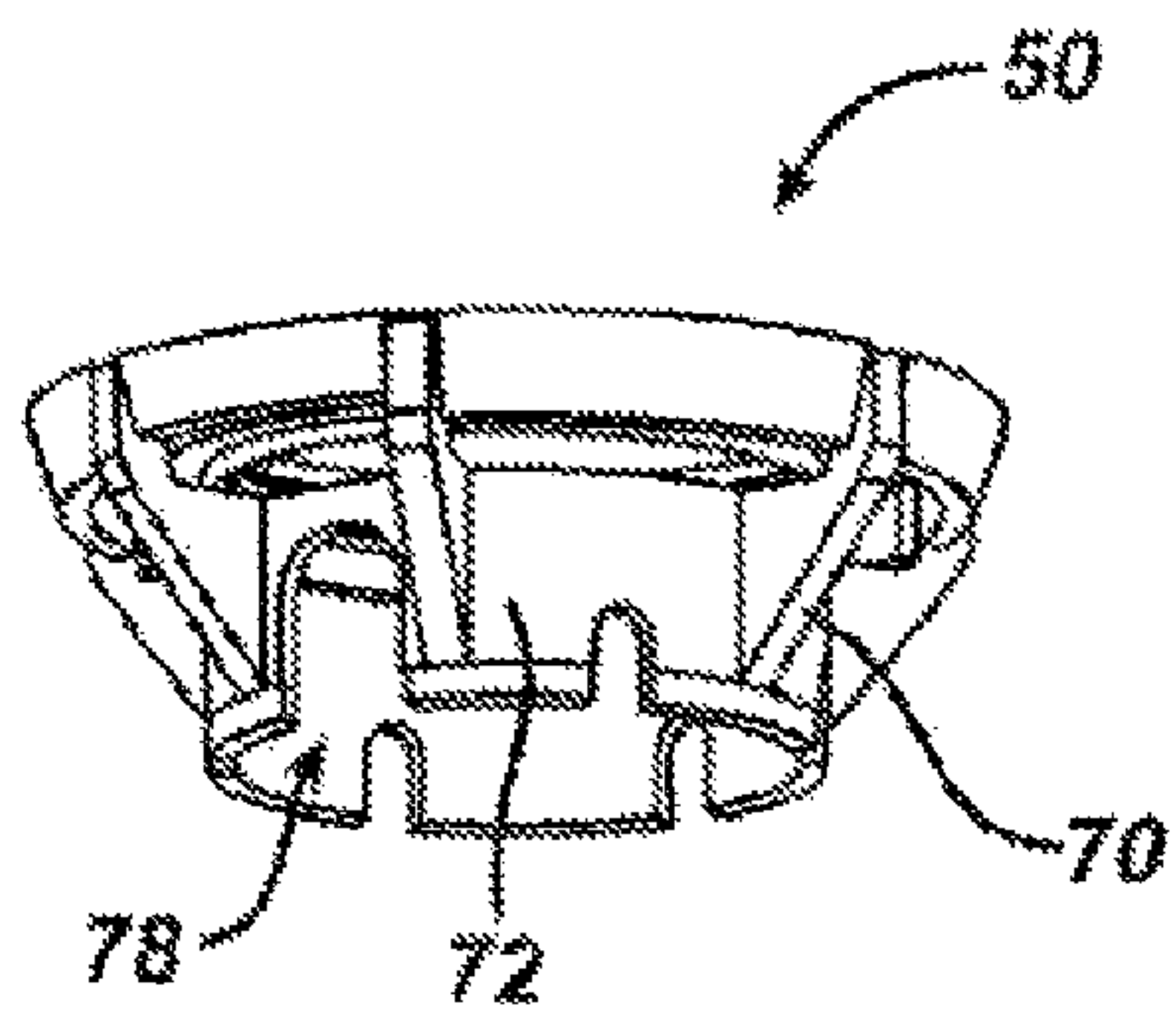
**FIG. 1H**



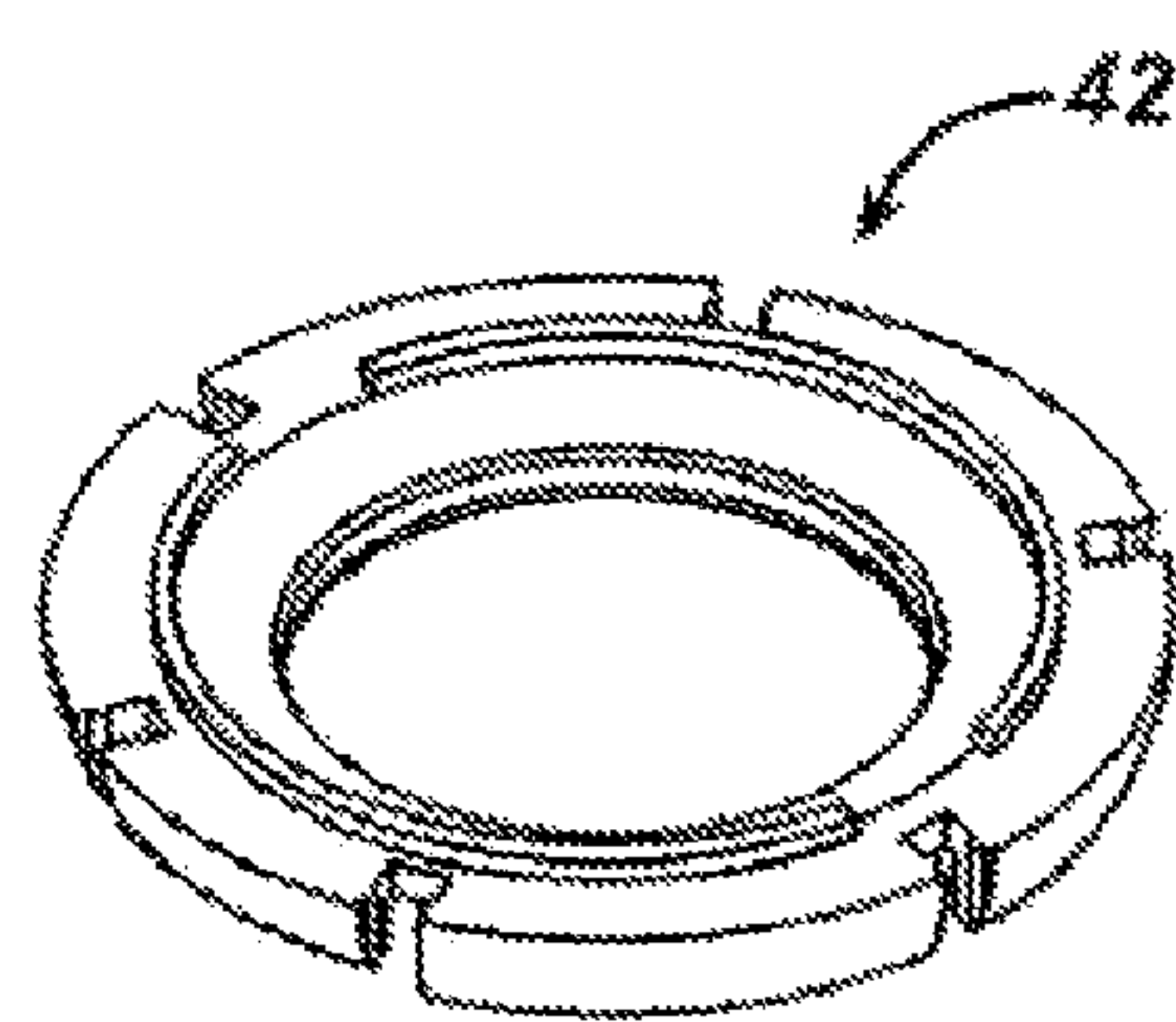
**FIG. 1I**



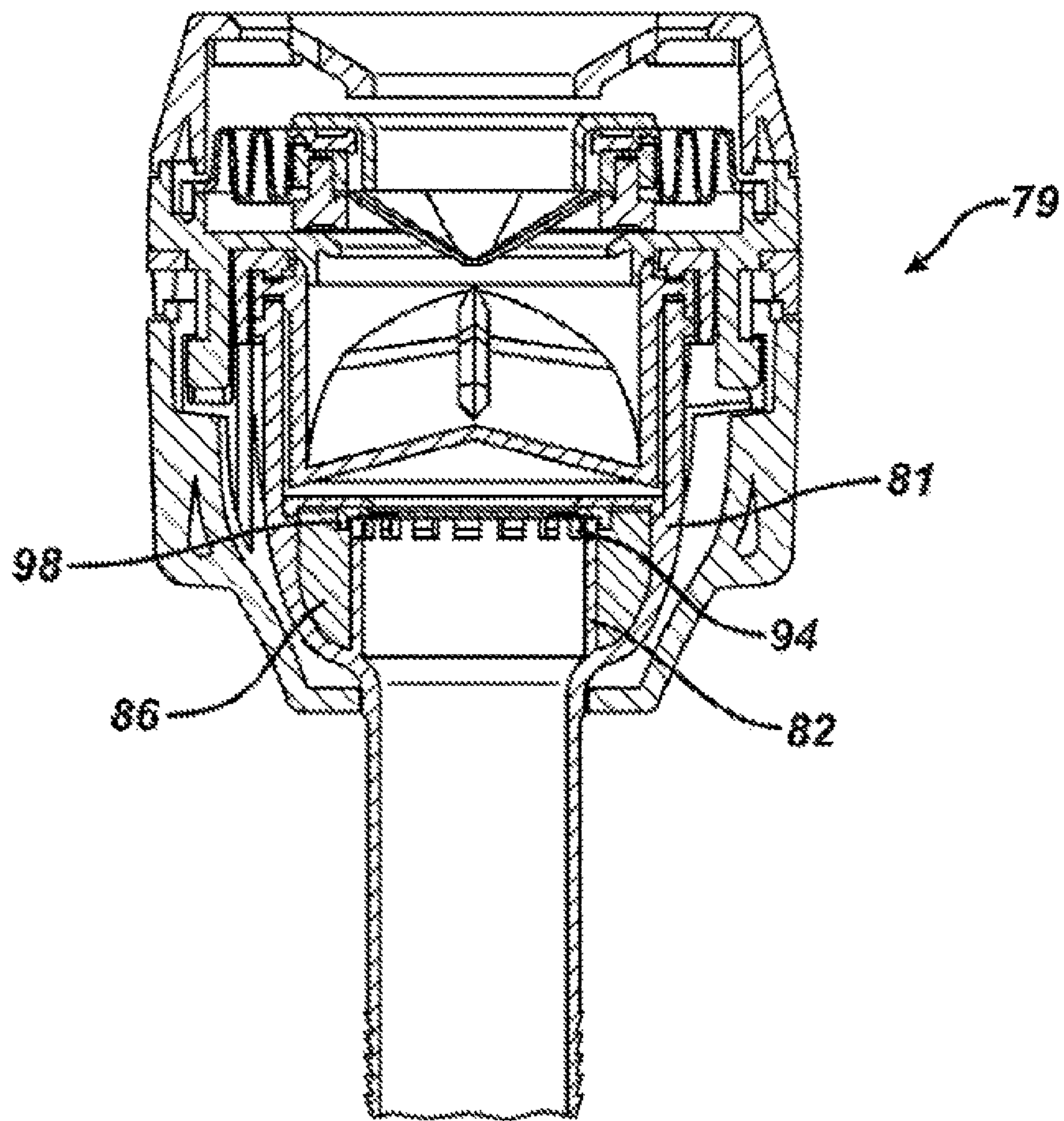
**FIG. 1J**



**FIG. 1K**



**FIG. 2A**





**FIG. 2B**

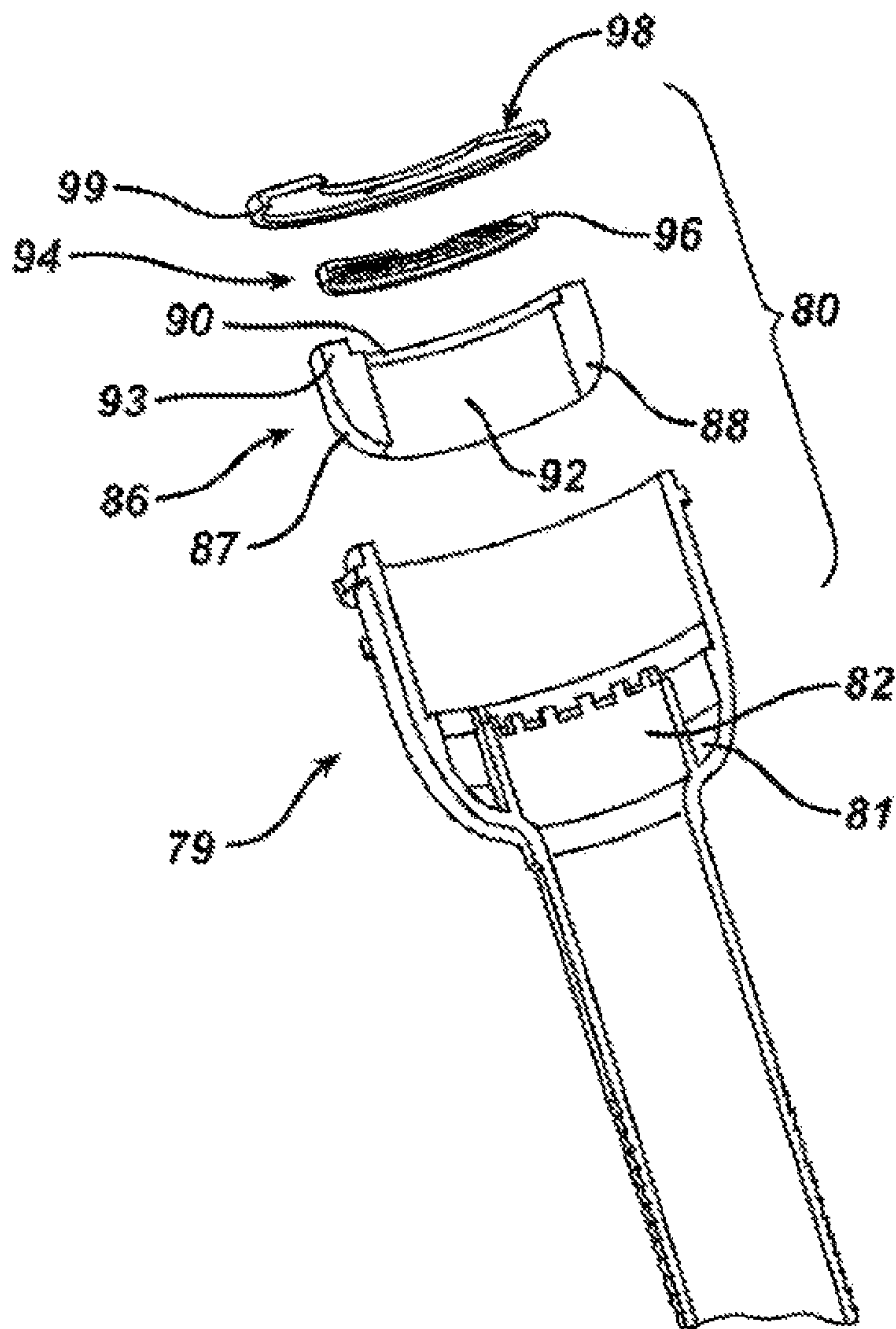


FIG. 3A

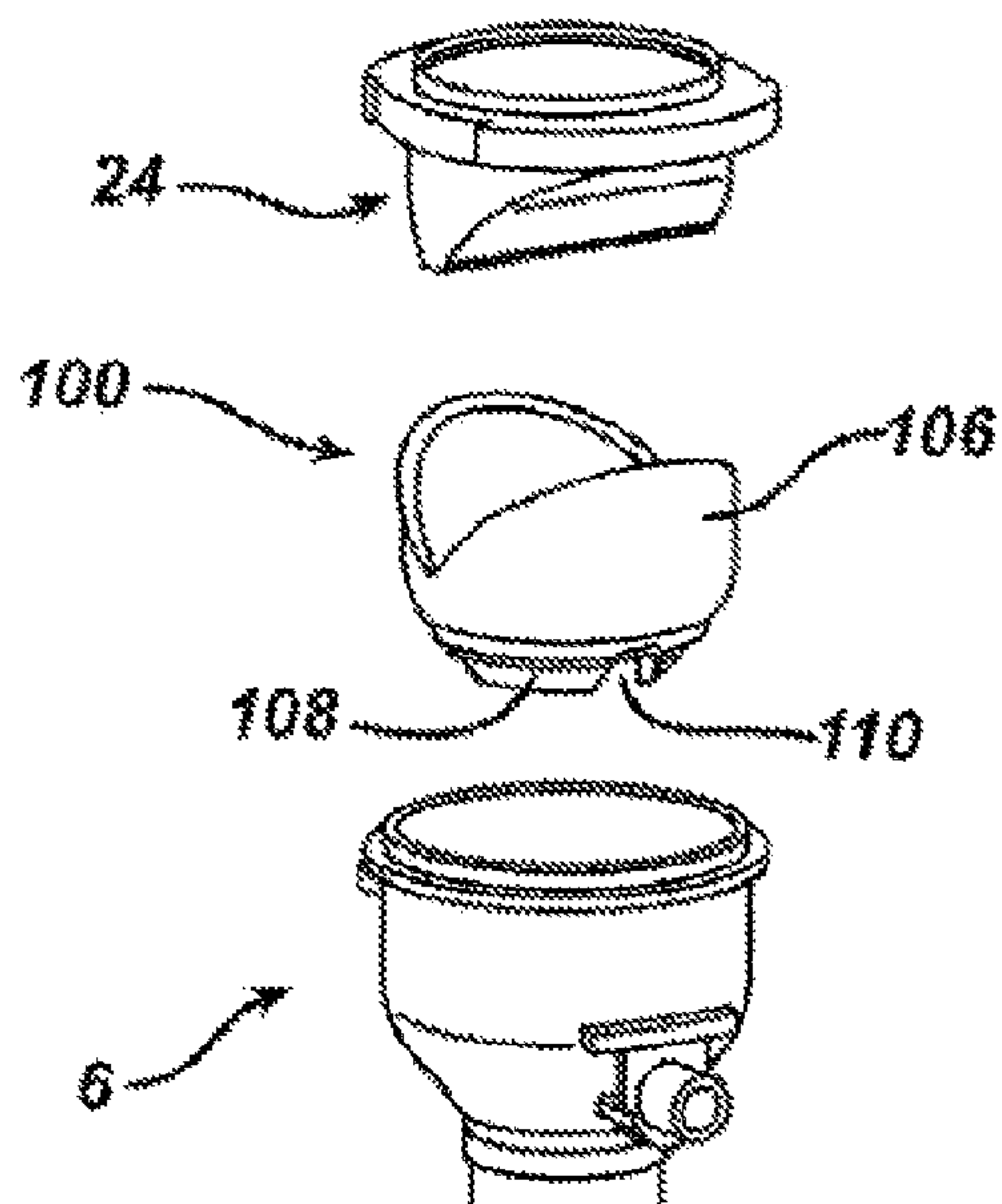


FIG. 3B

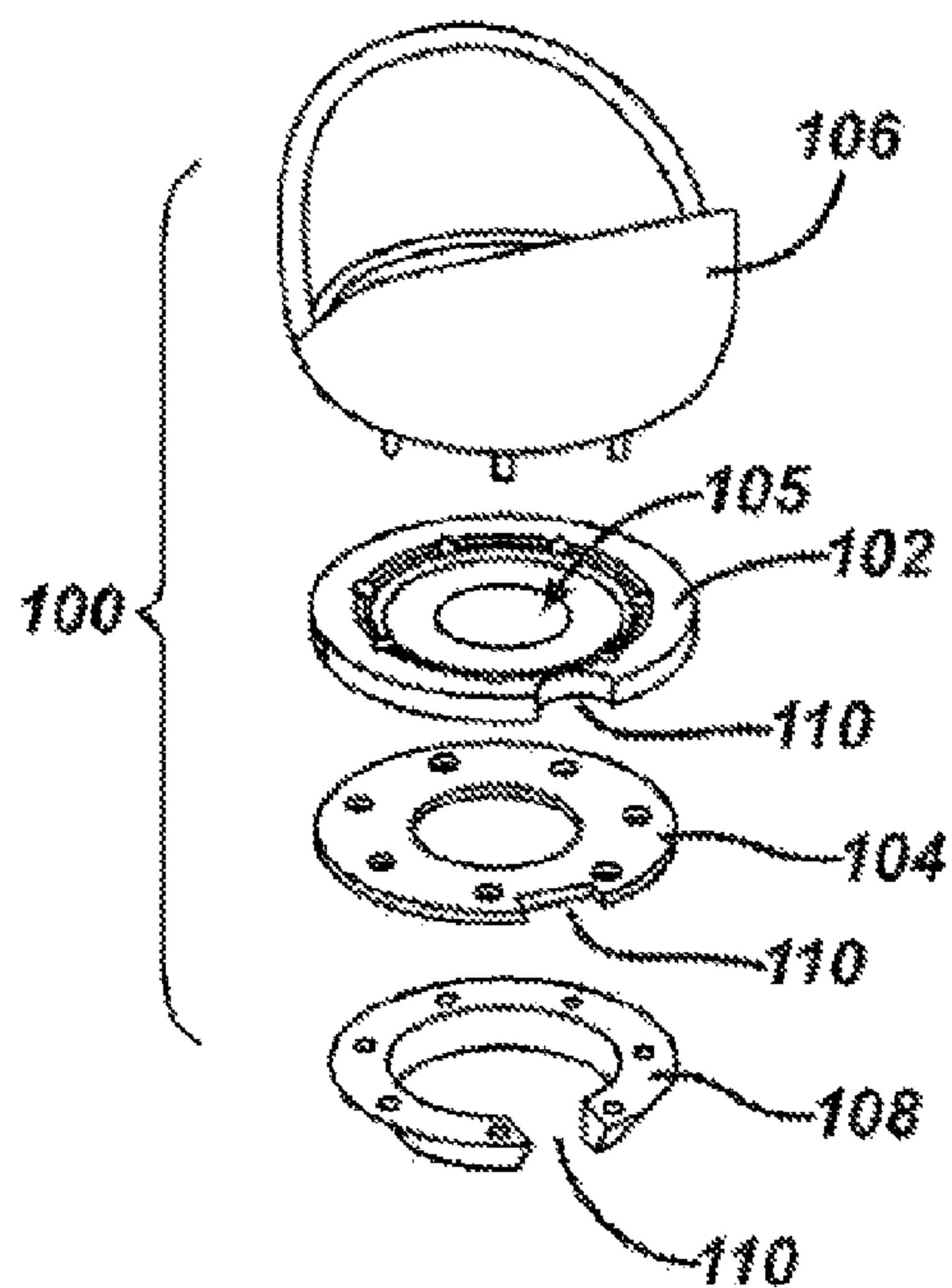
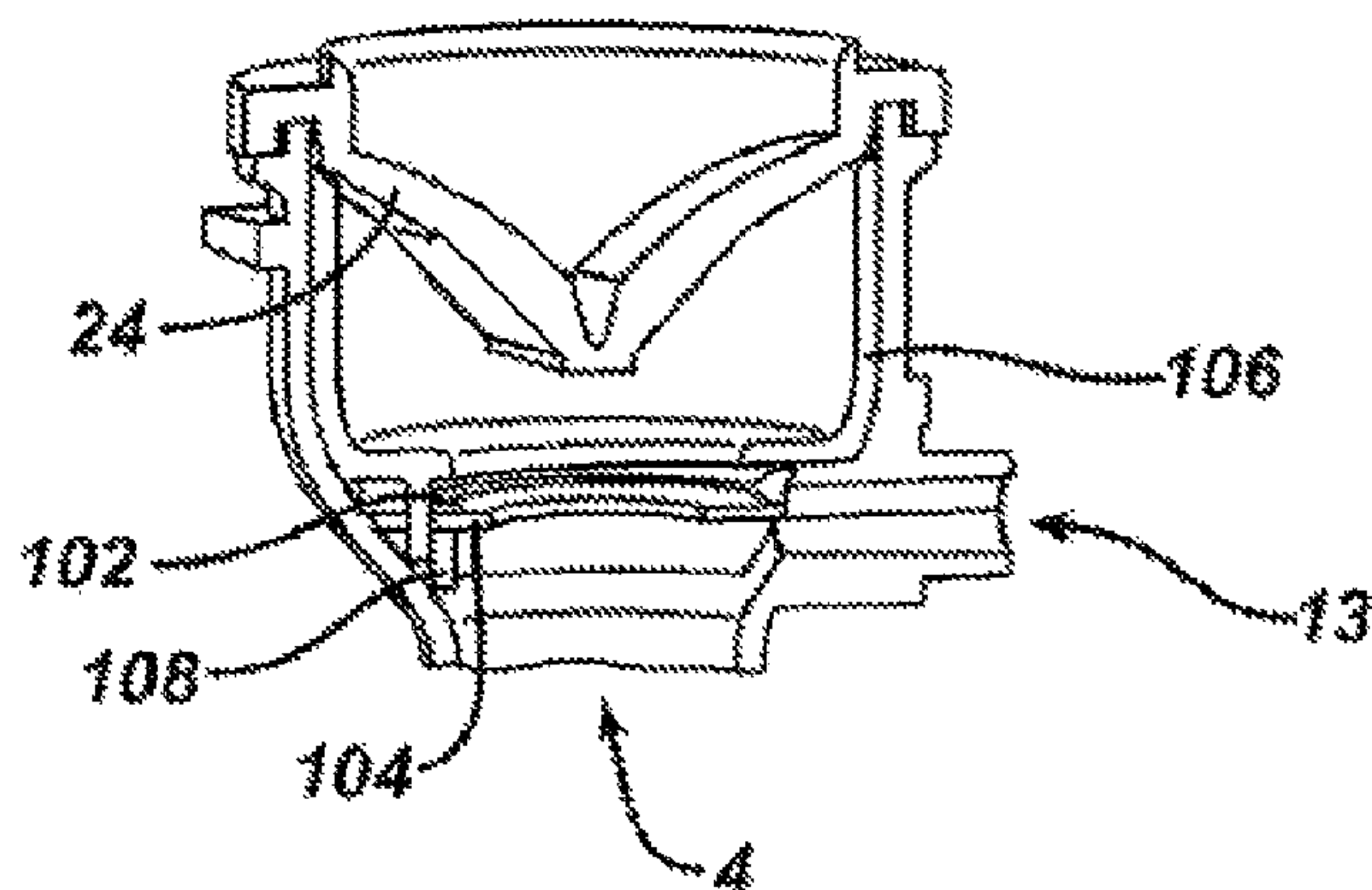
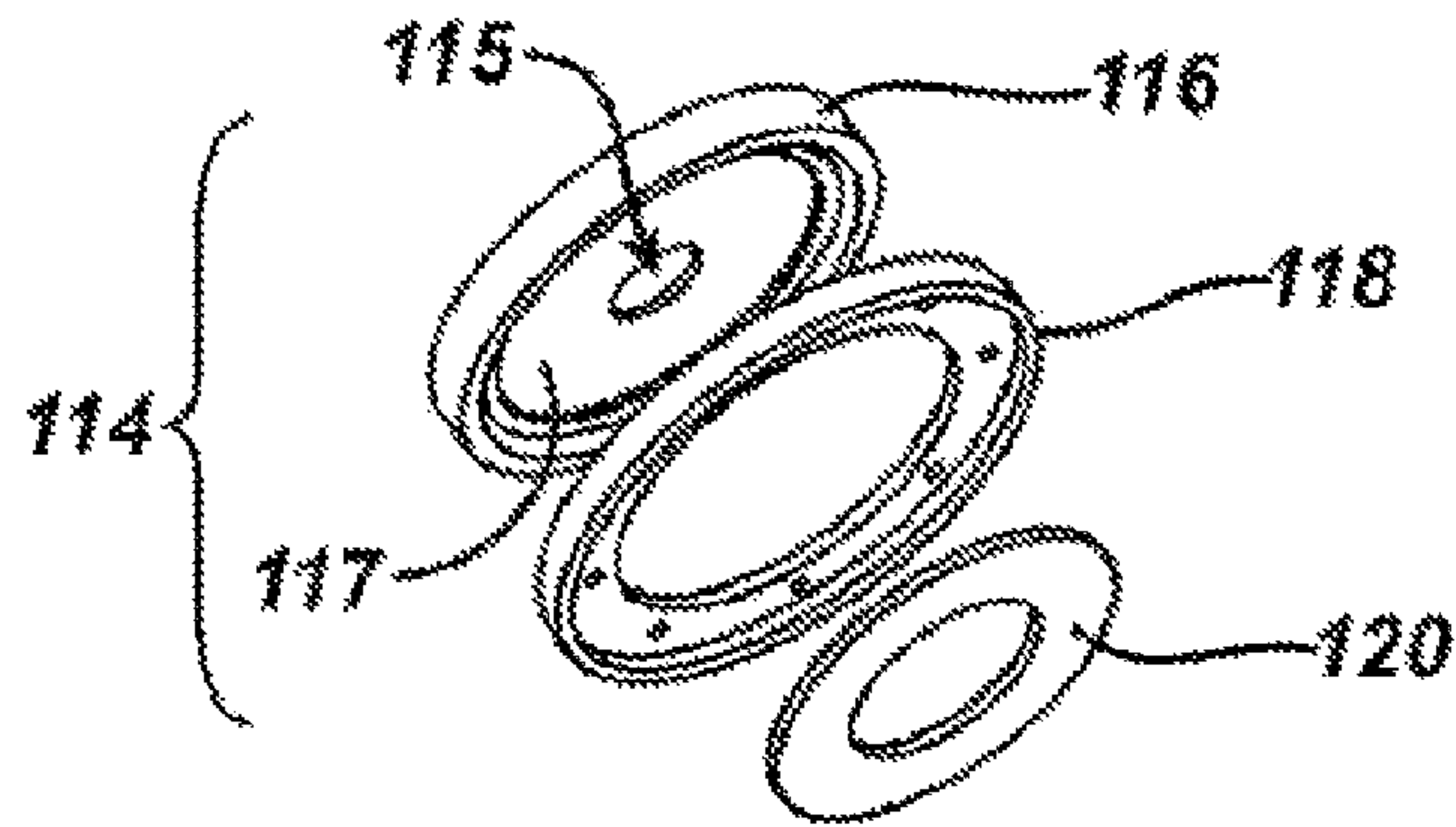


FIG. 3C

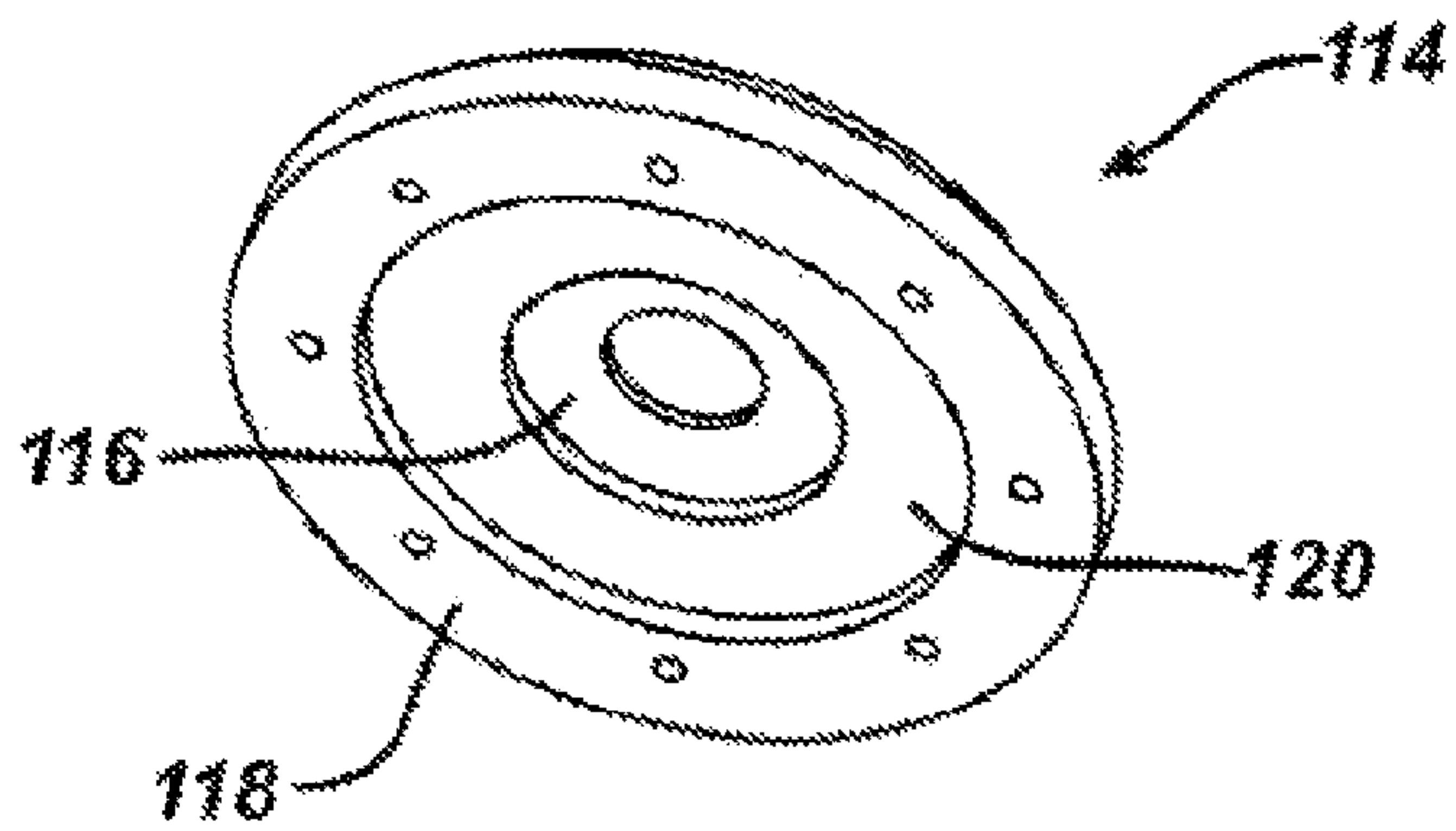




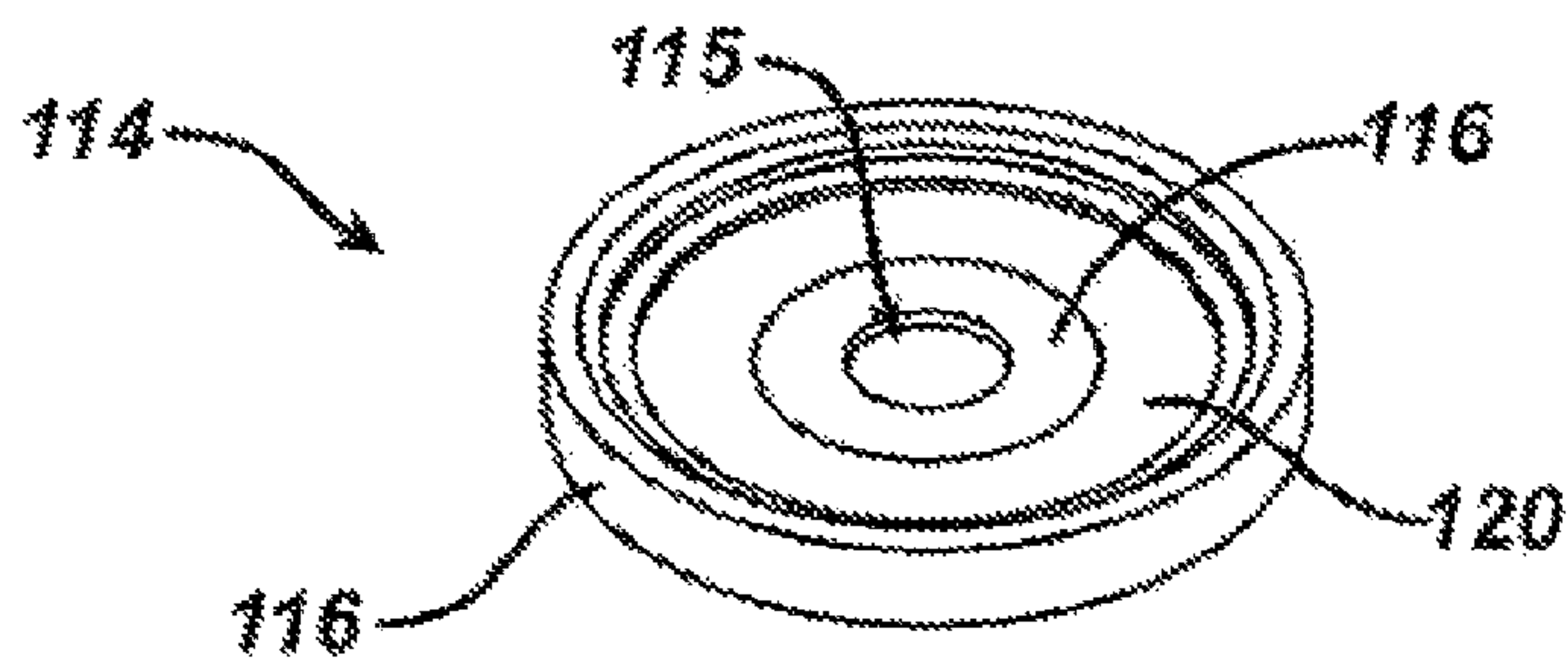
**FIG. 4A**



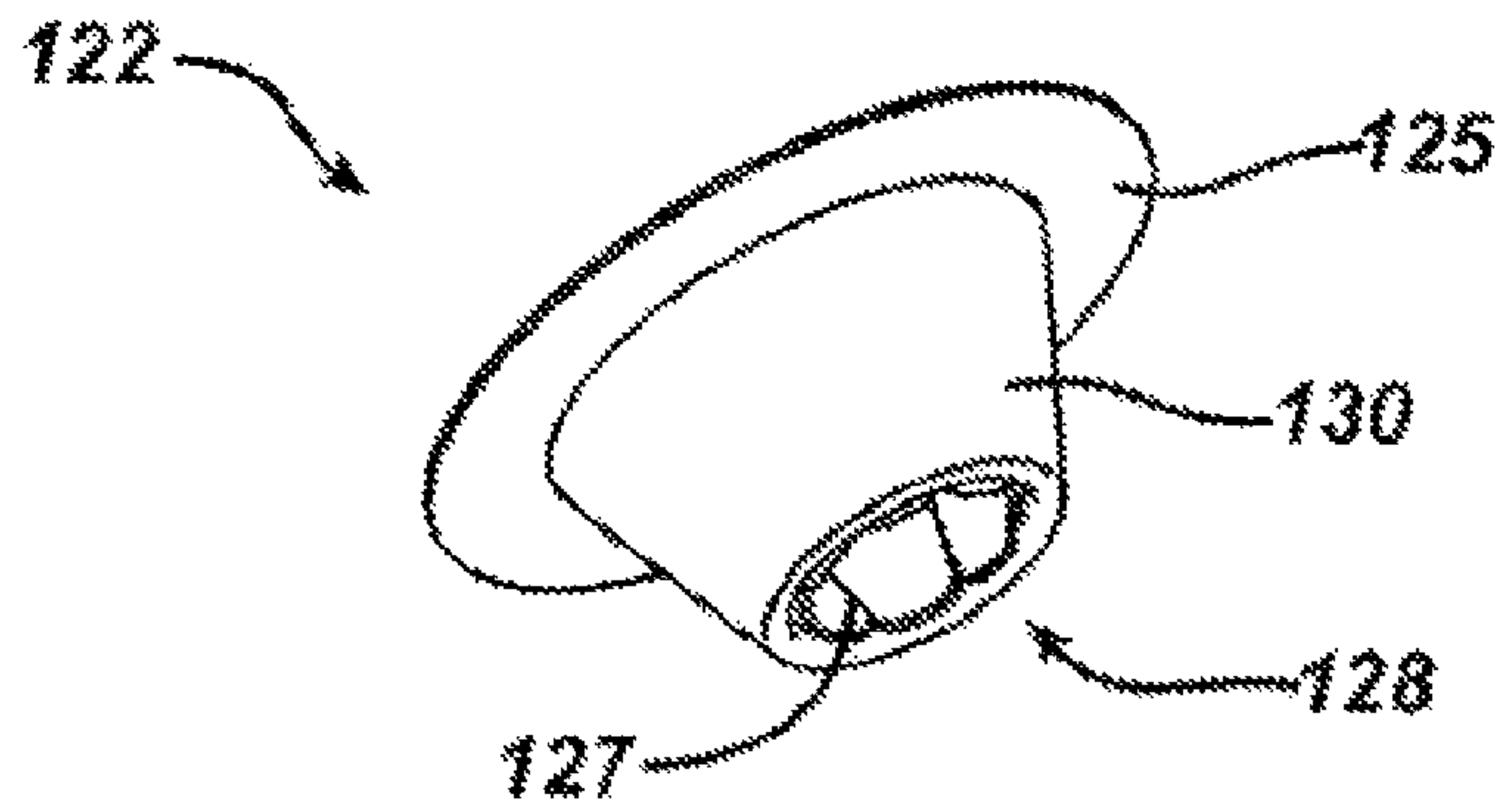
**FIG. 4B**



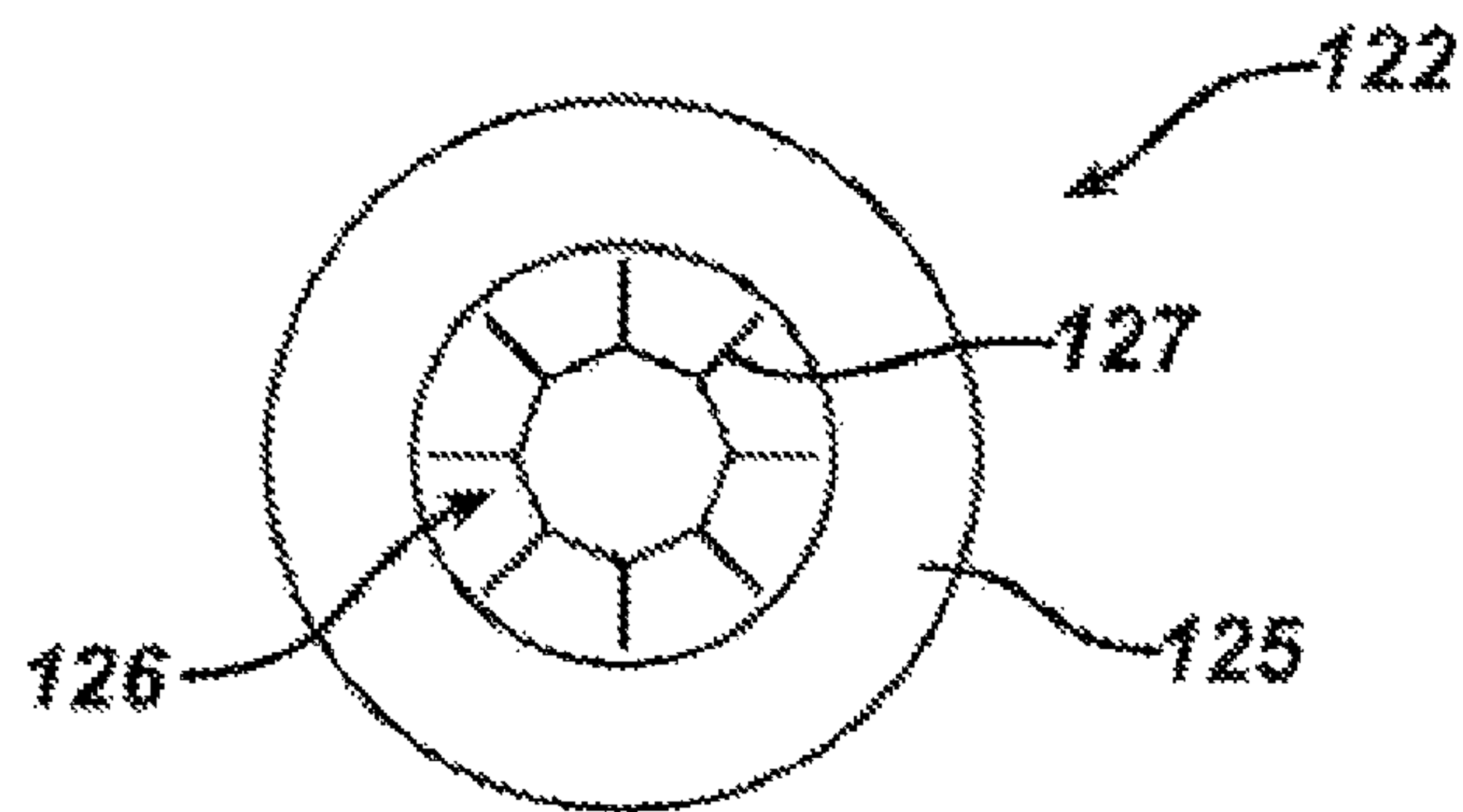
**FIG. 4C**



**FIG. 5A**



**FIG. 5B**



**FIG. 5C**

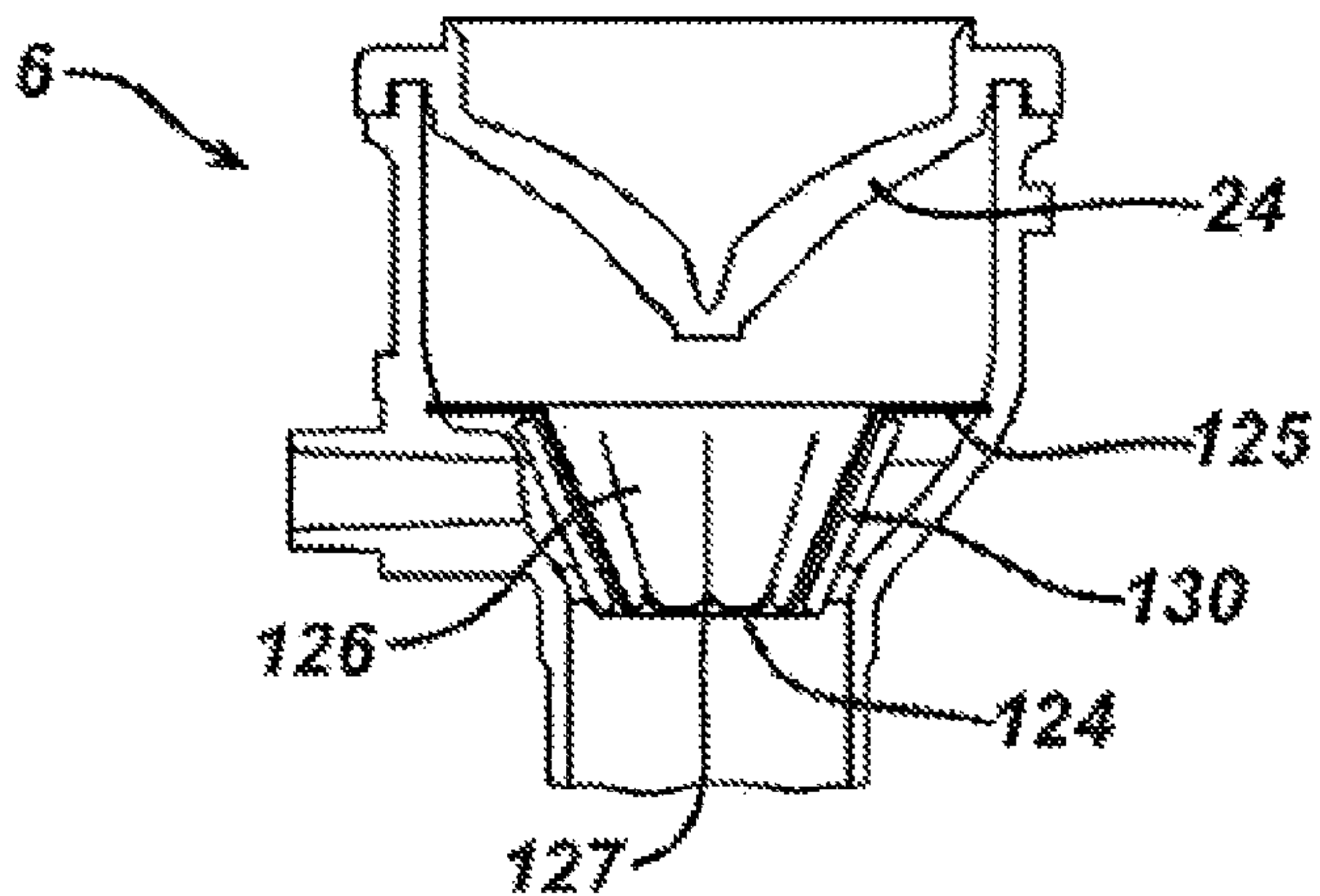




FIG. 6C

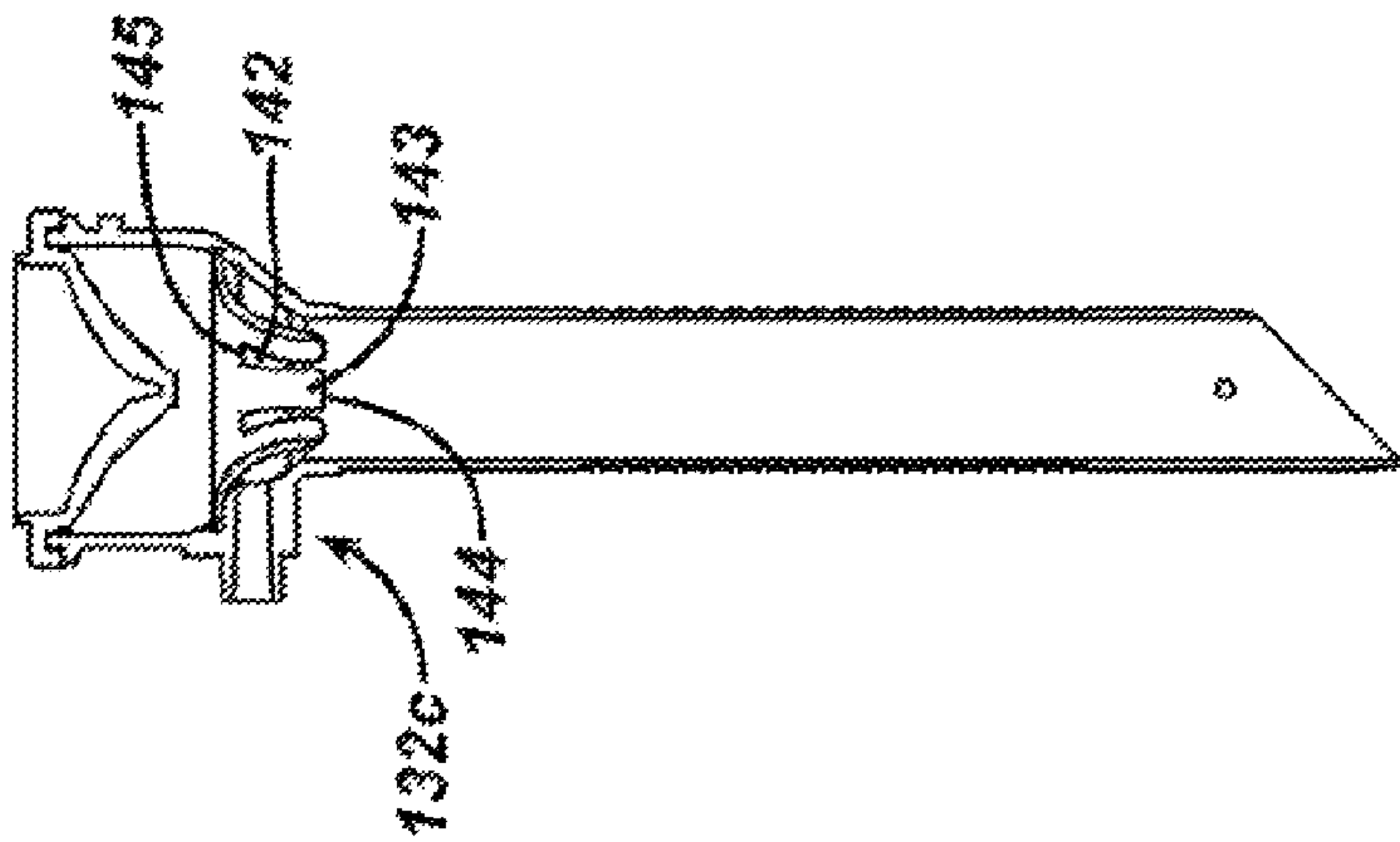


FIG. 6B

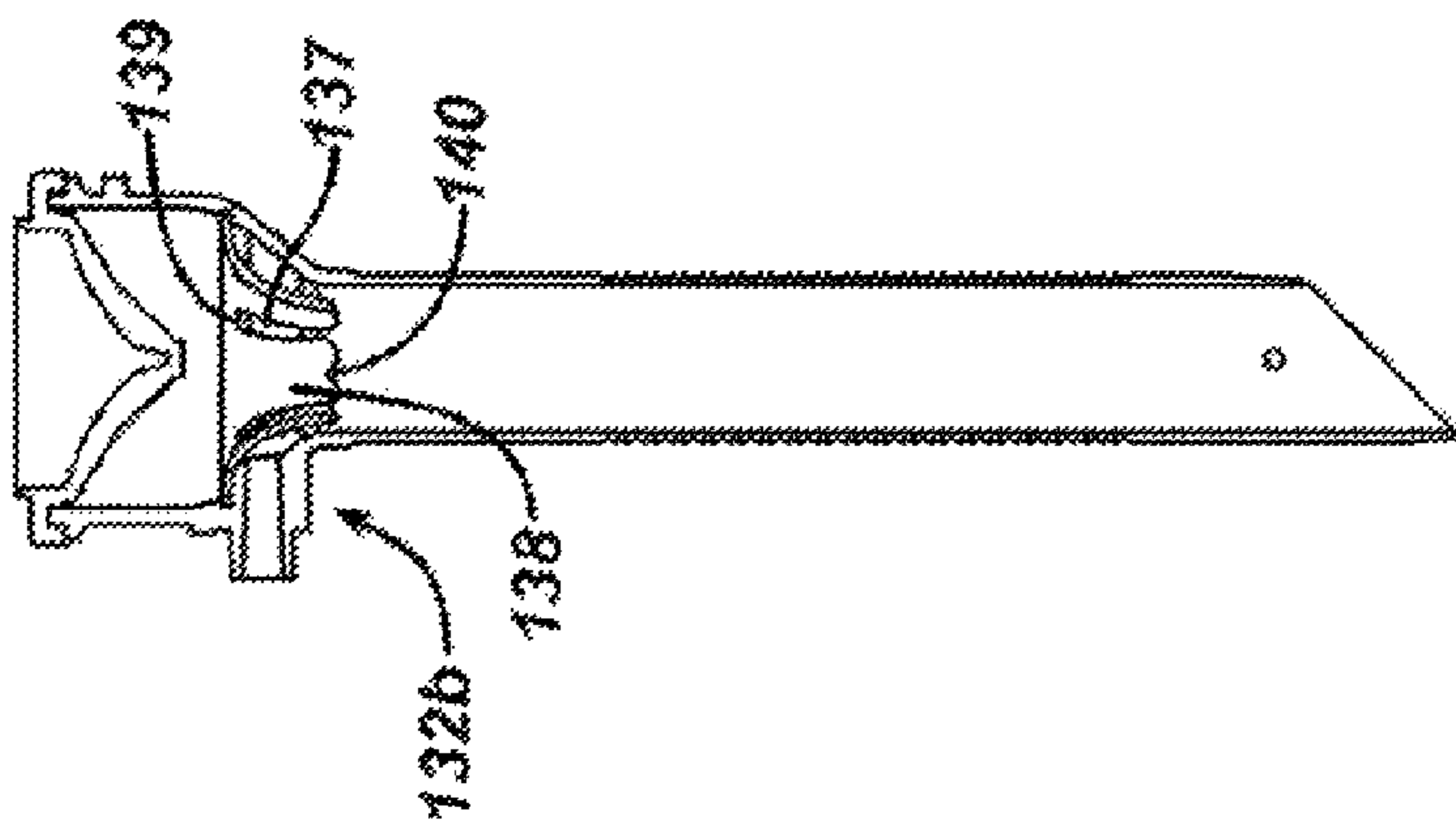
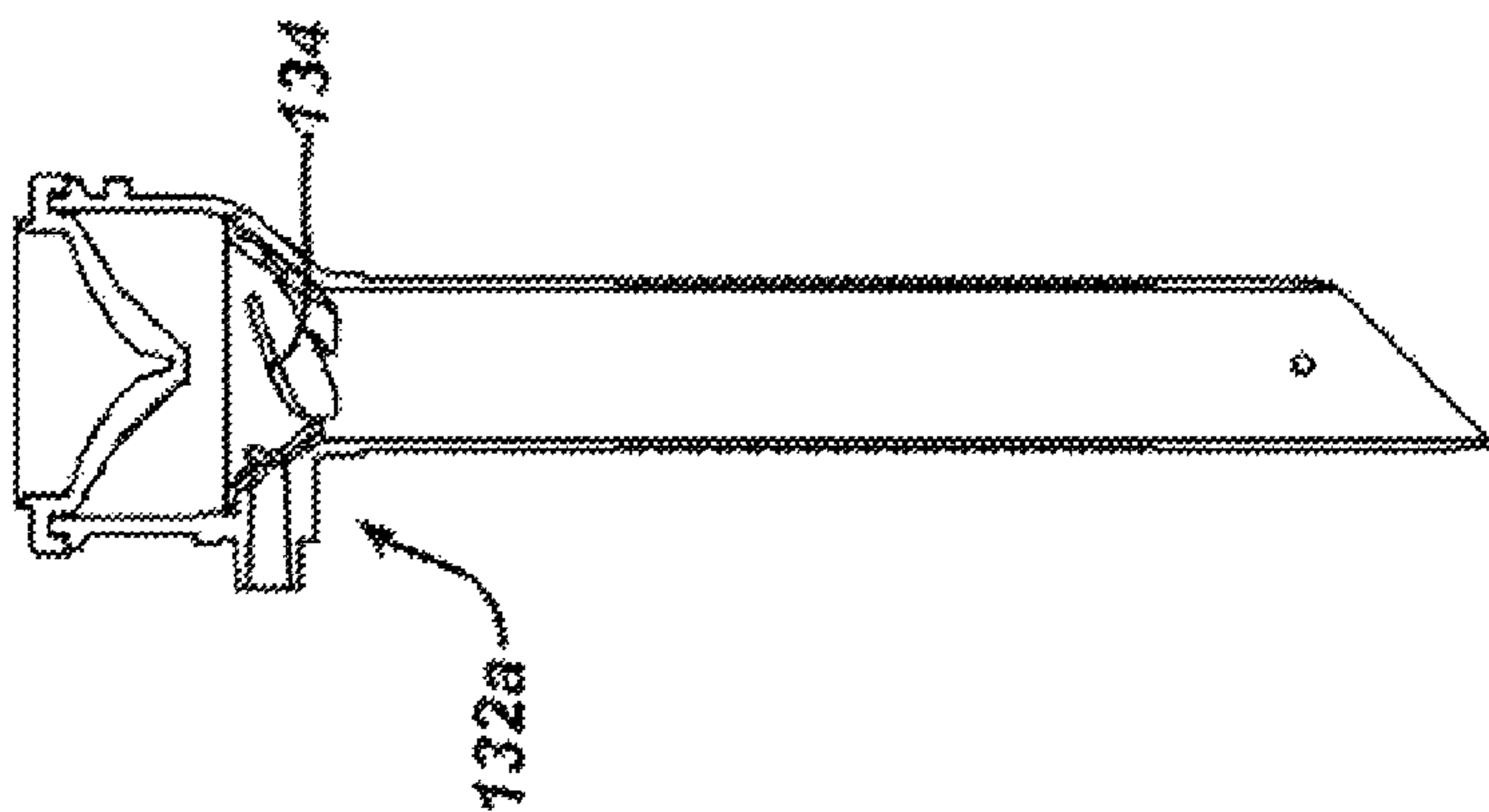
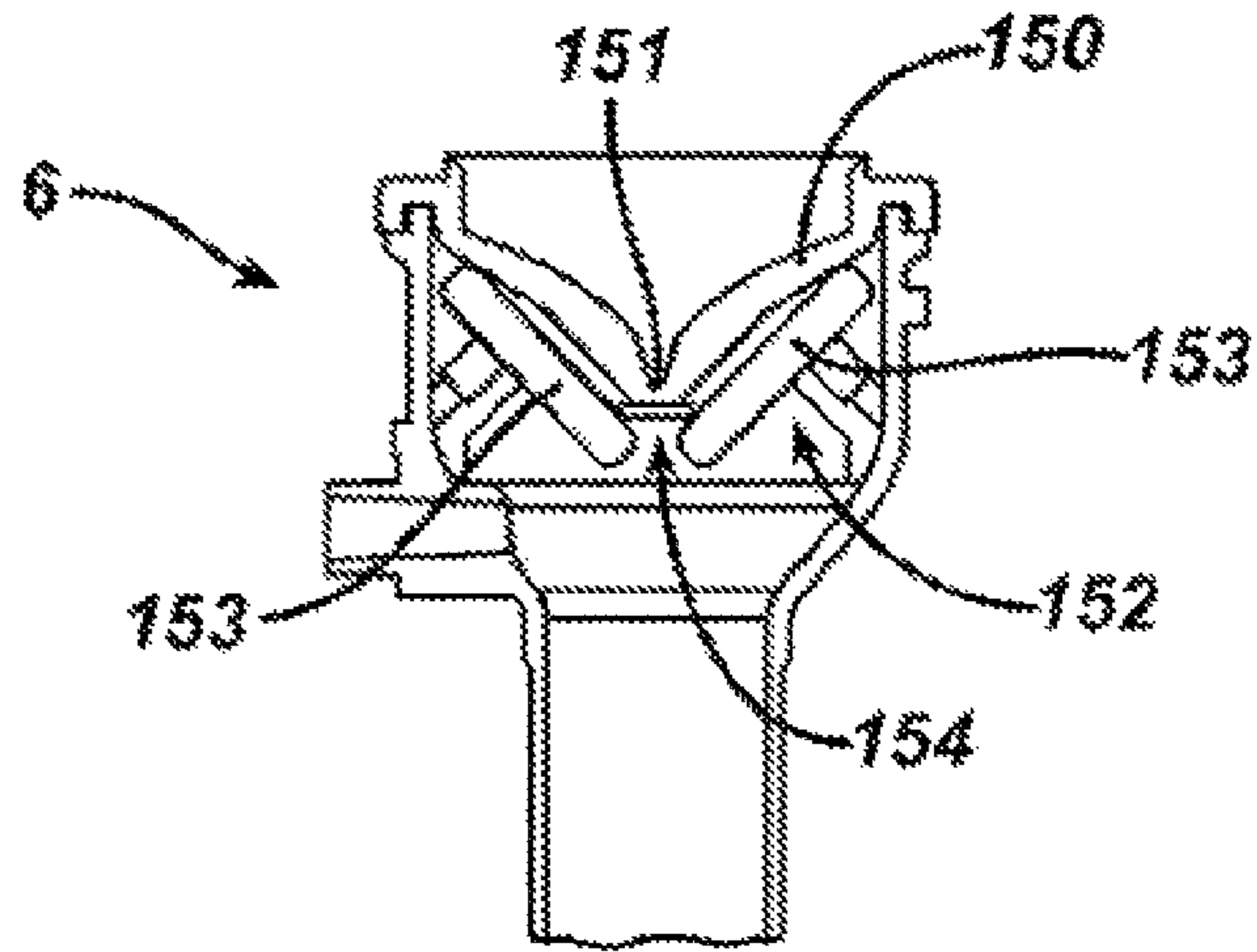


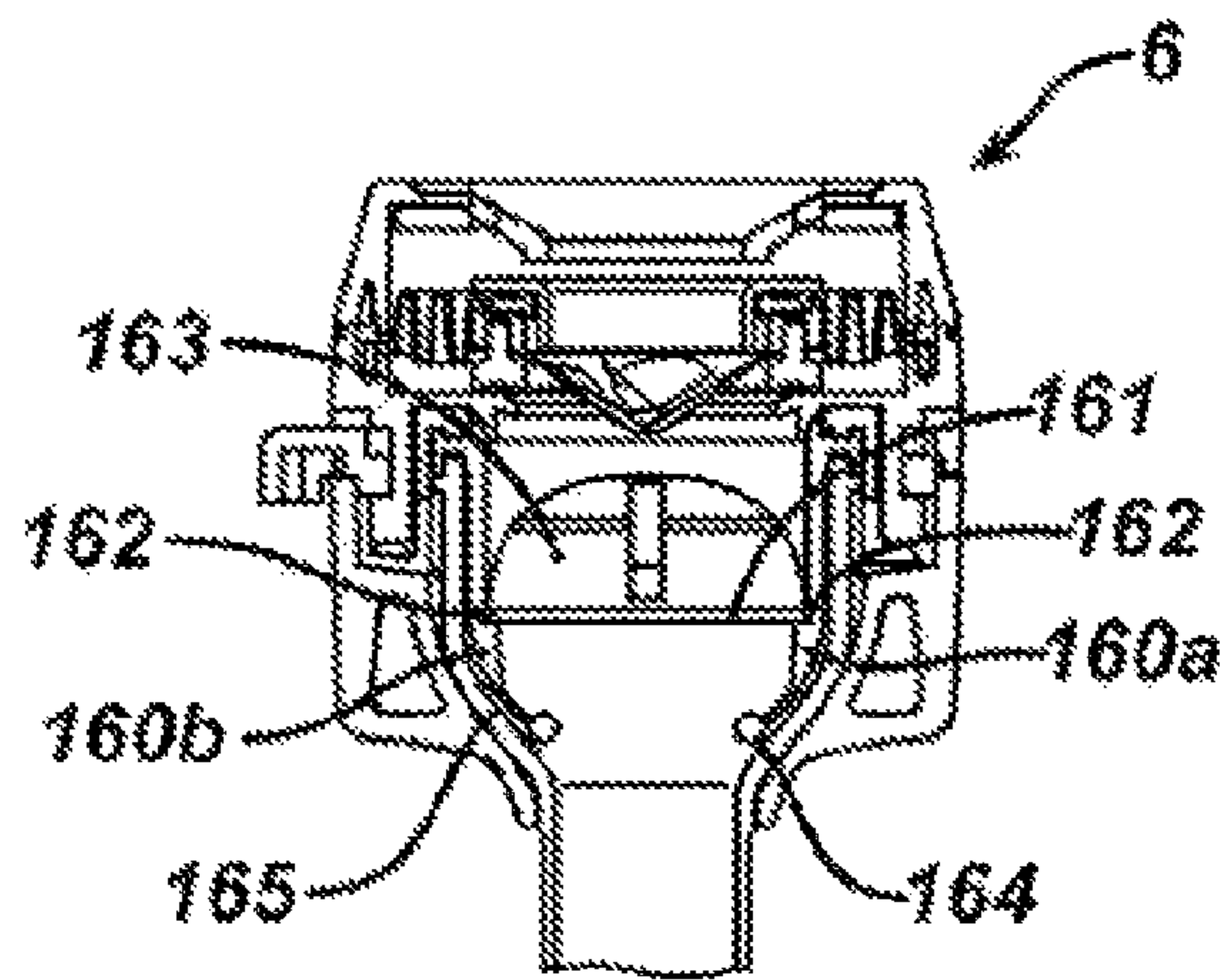
FIG. 6A



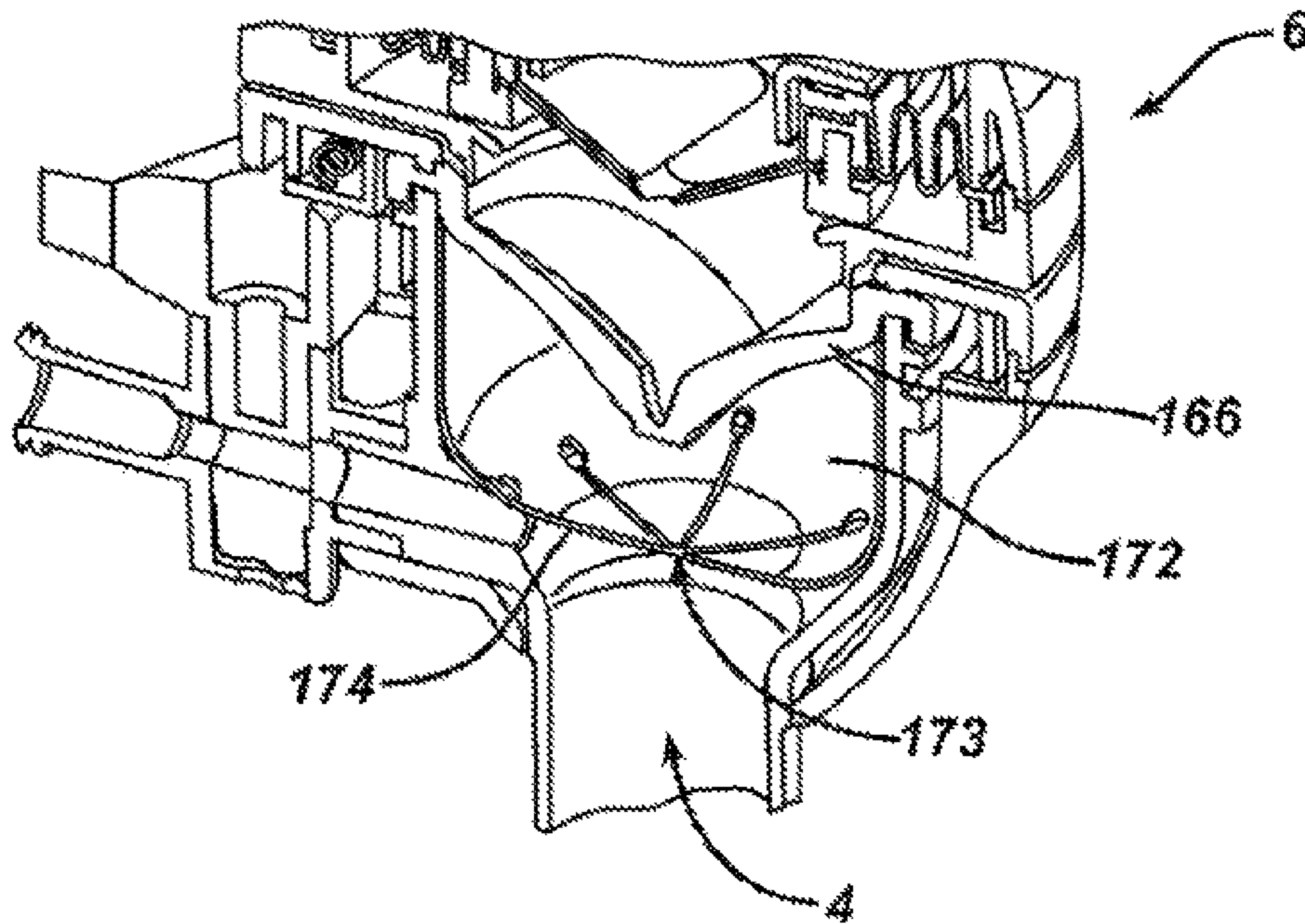
**FIG. 7**



**FIG. 8**

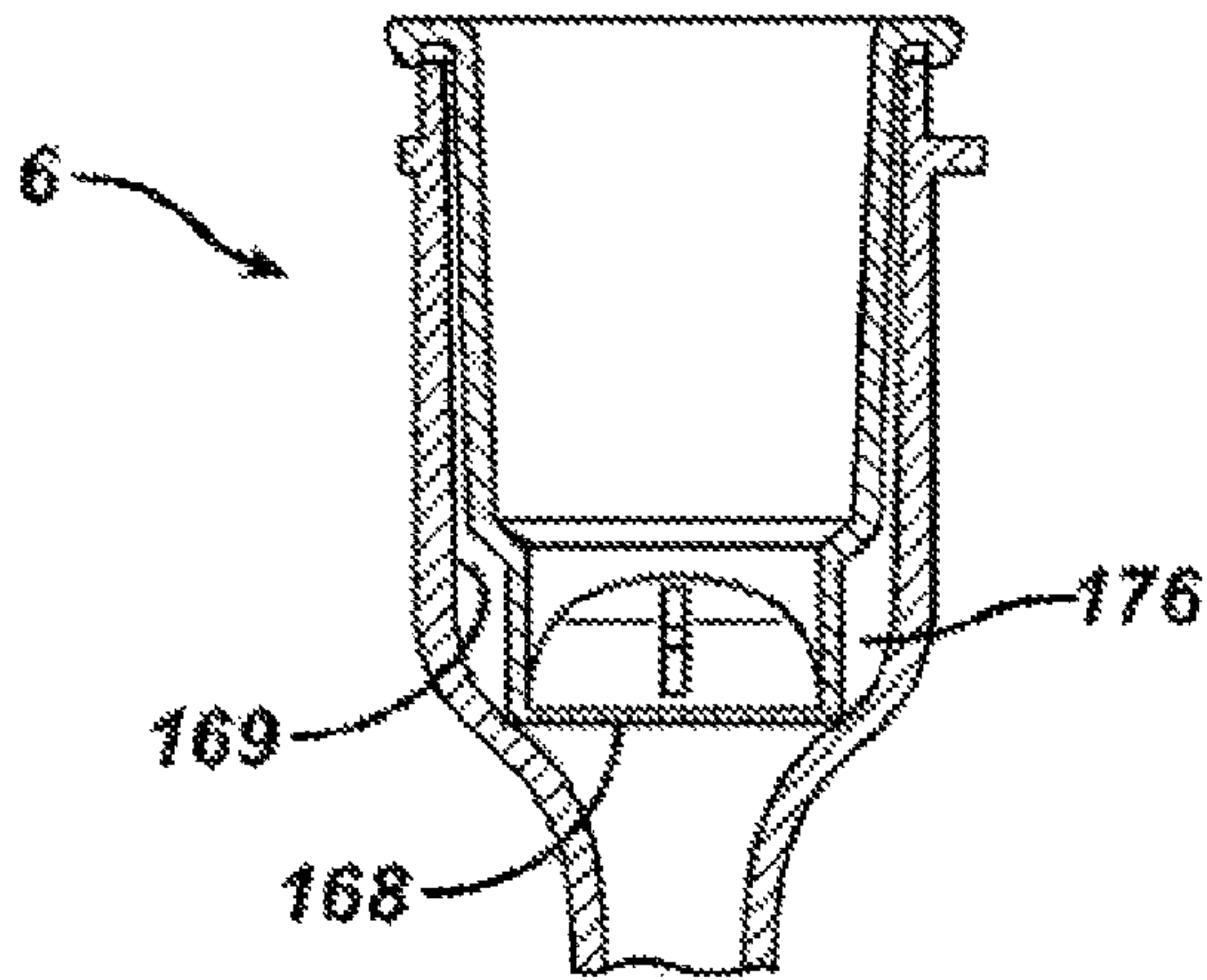


**FIG. 9**

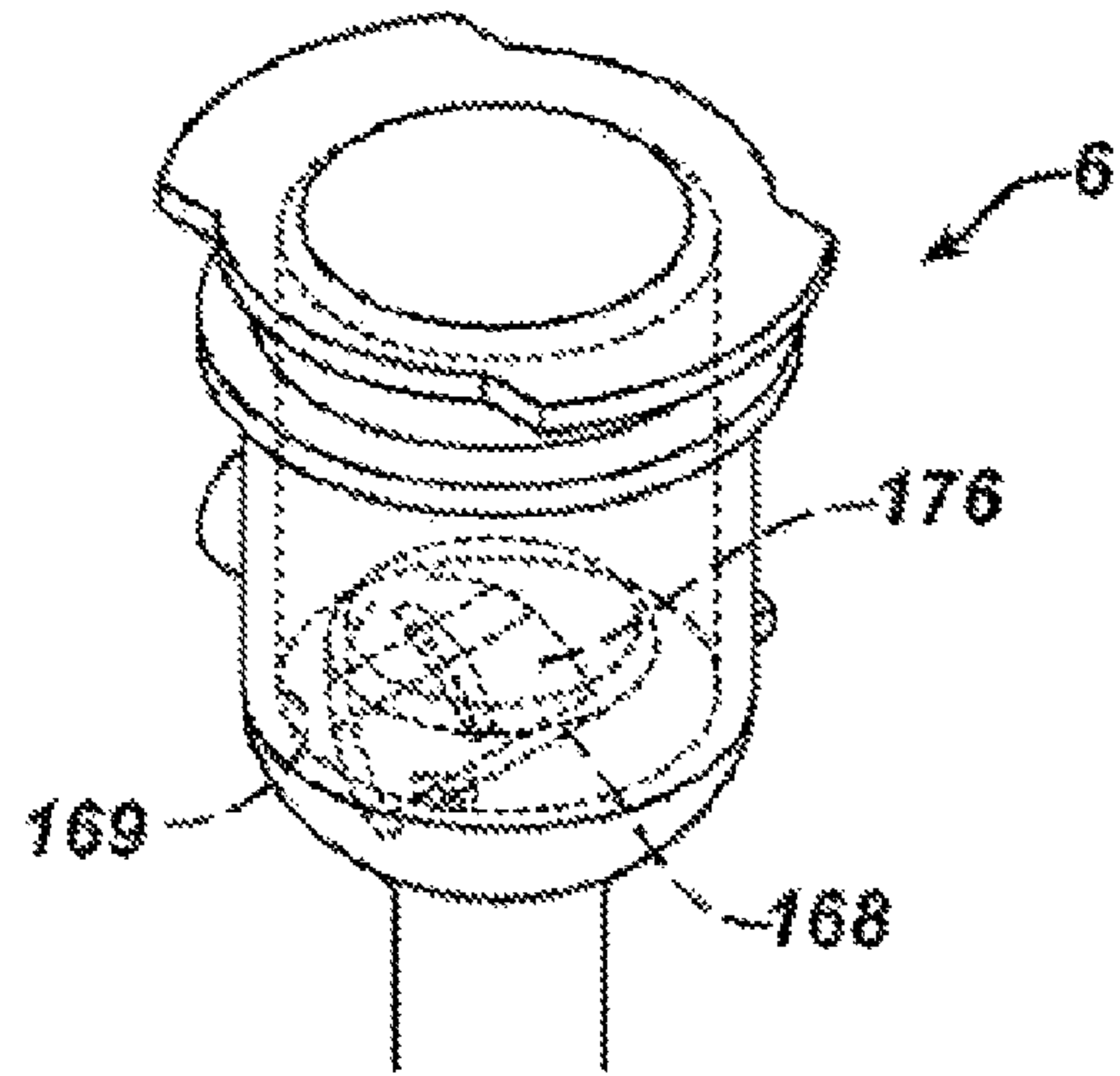




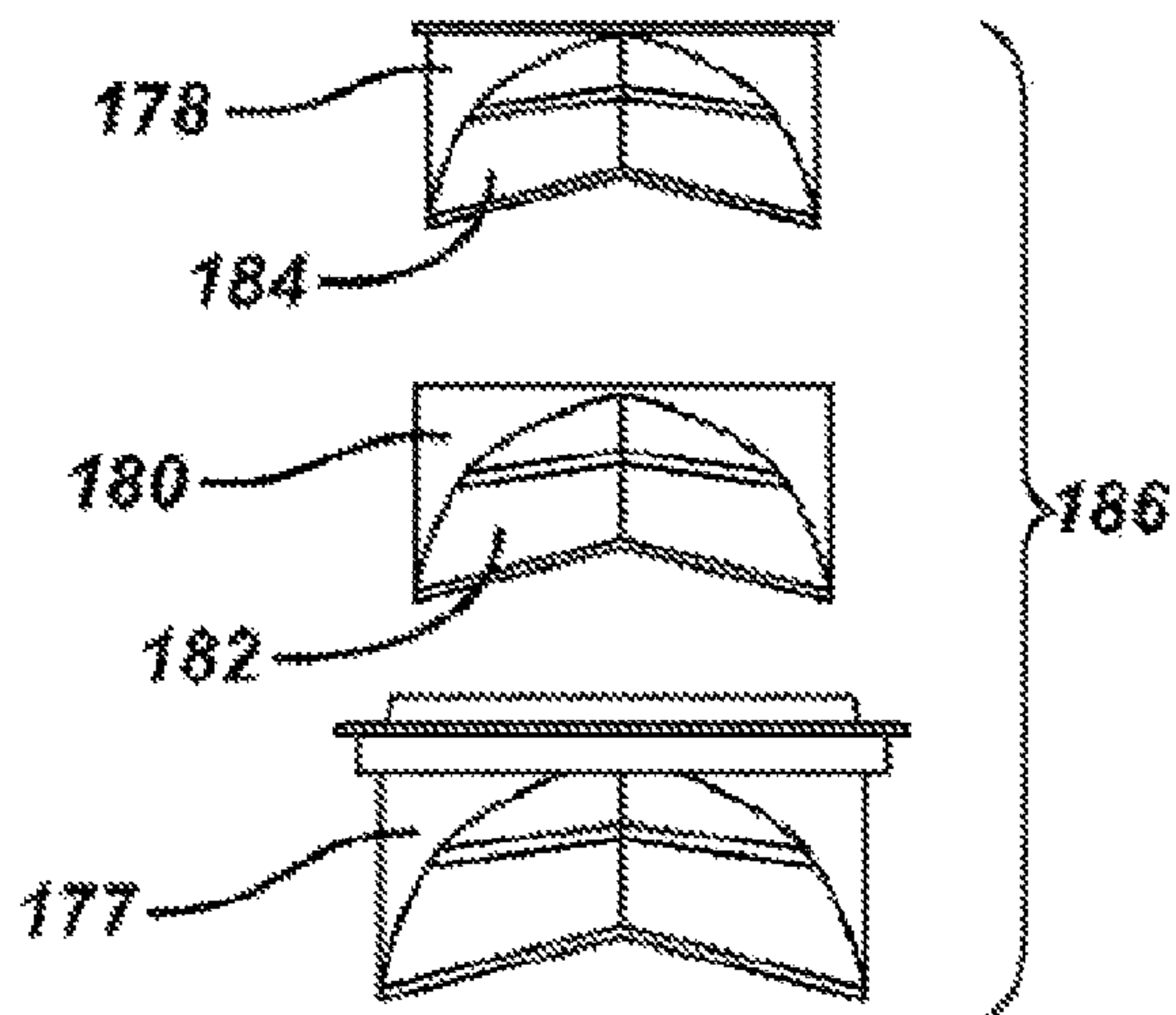
**FIG. 10A**



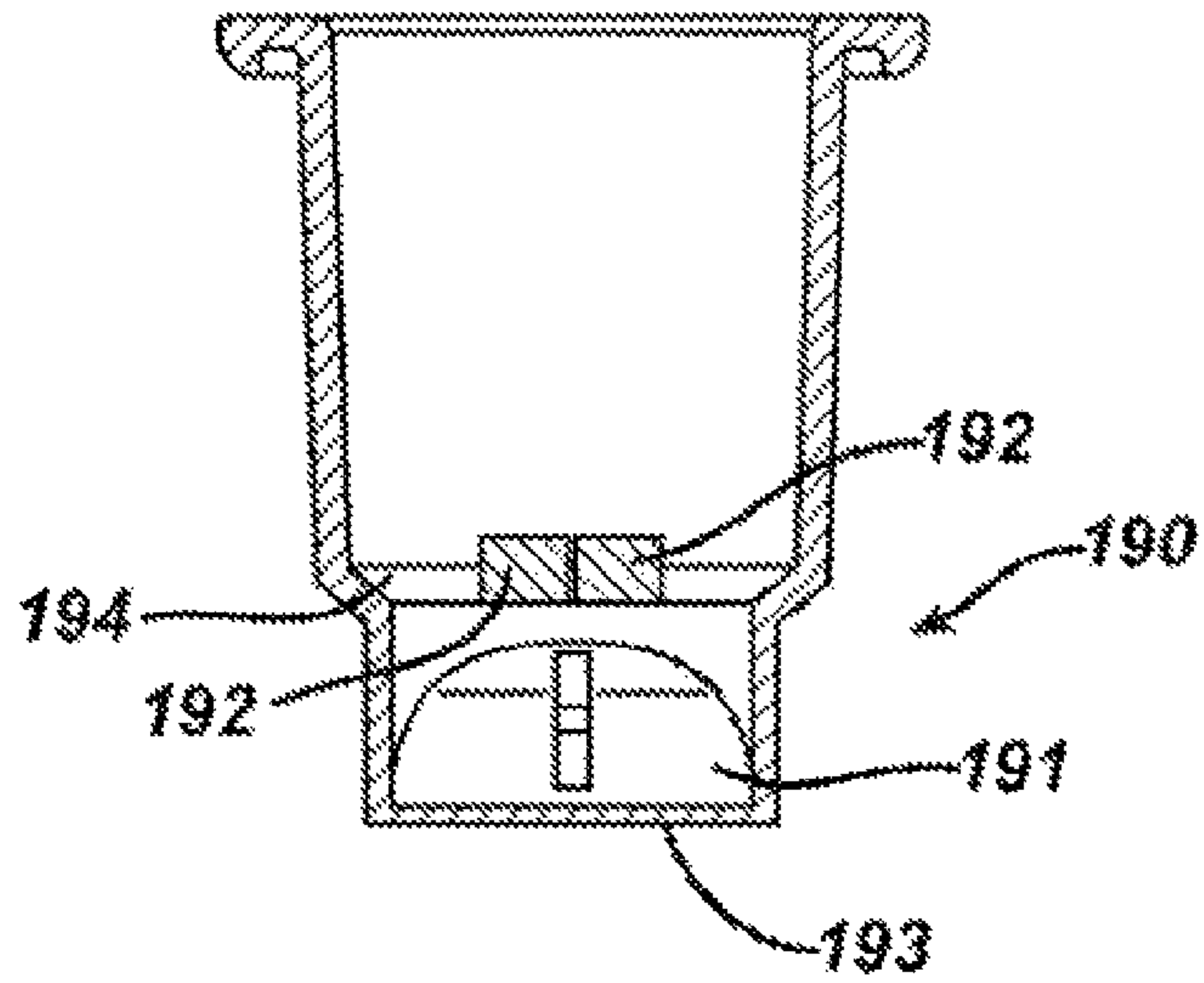
**FIG. 10B**



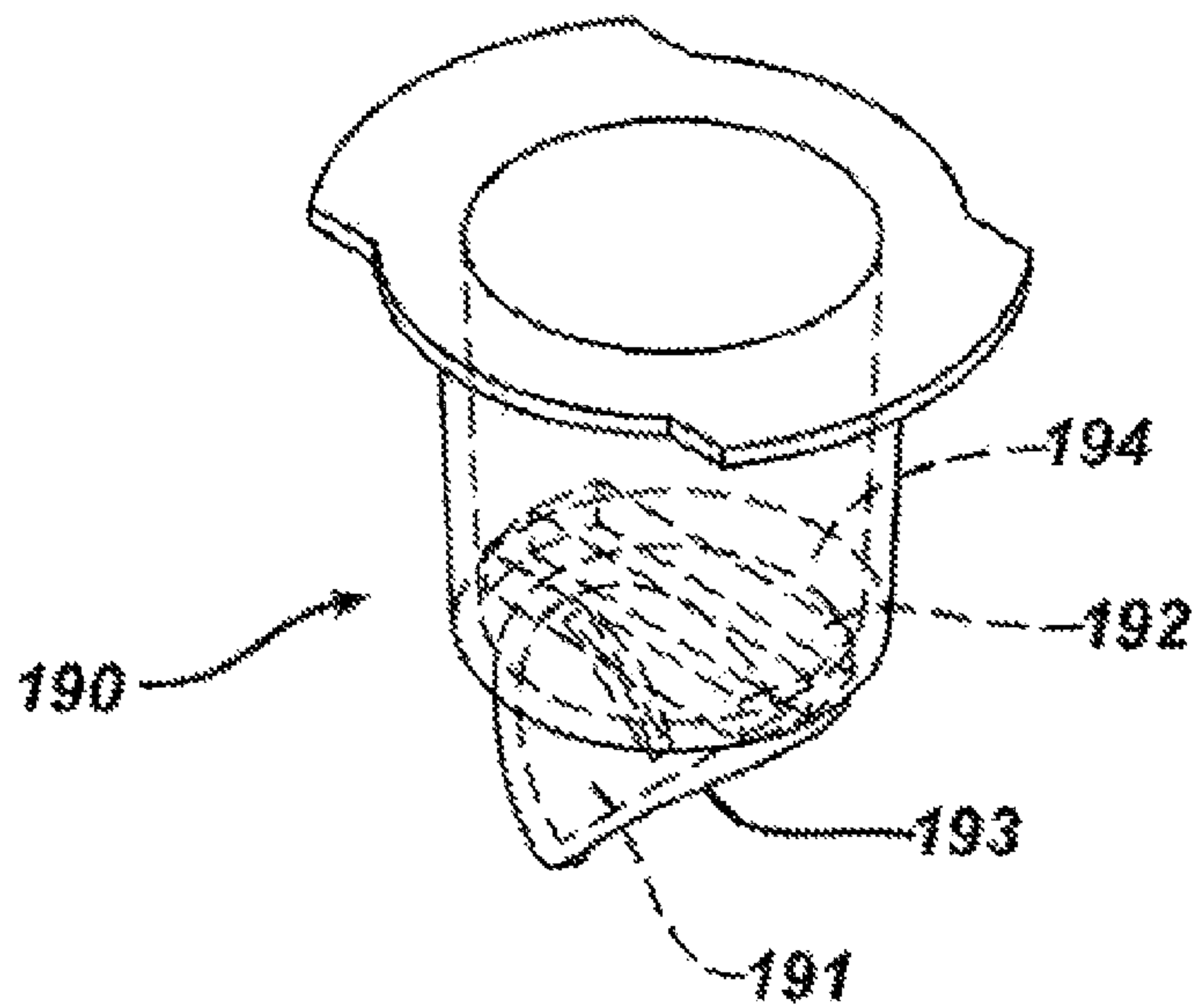
**FIG. 11**



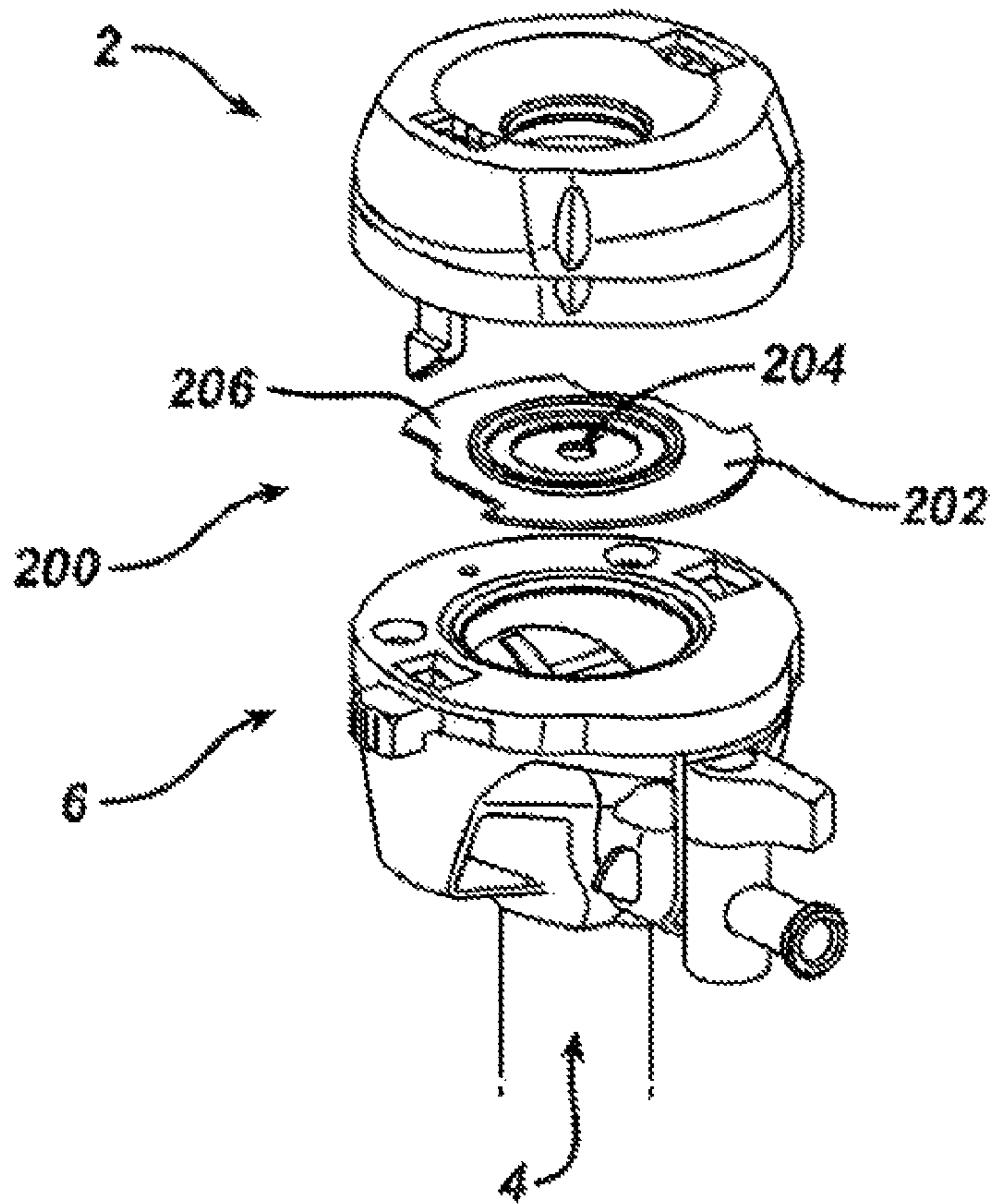
**FIG. 12A**



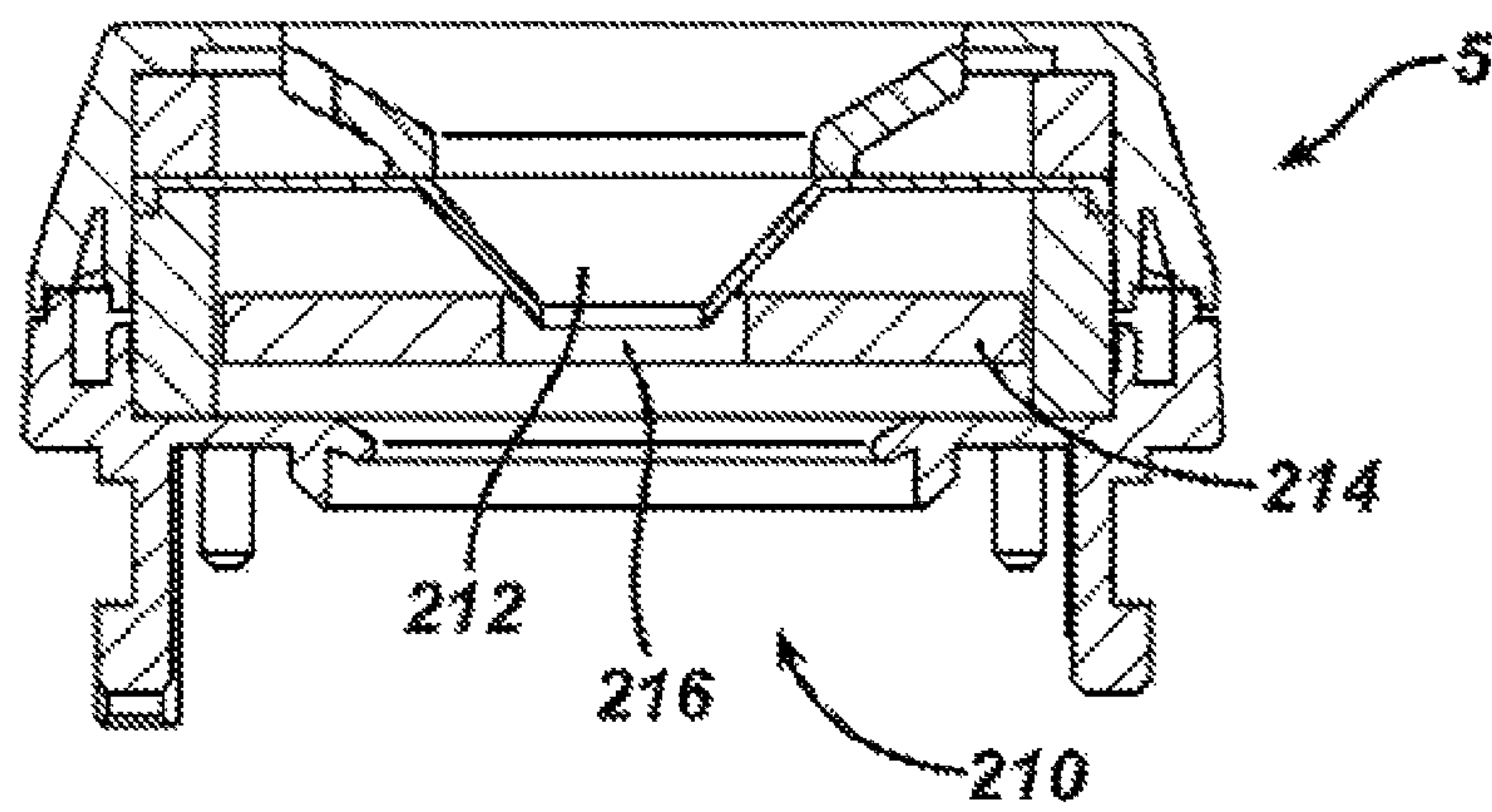
**FIG. 12B**



**FIG. 13**

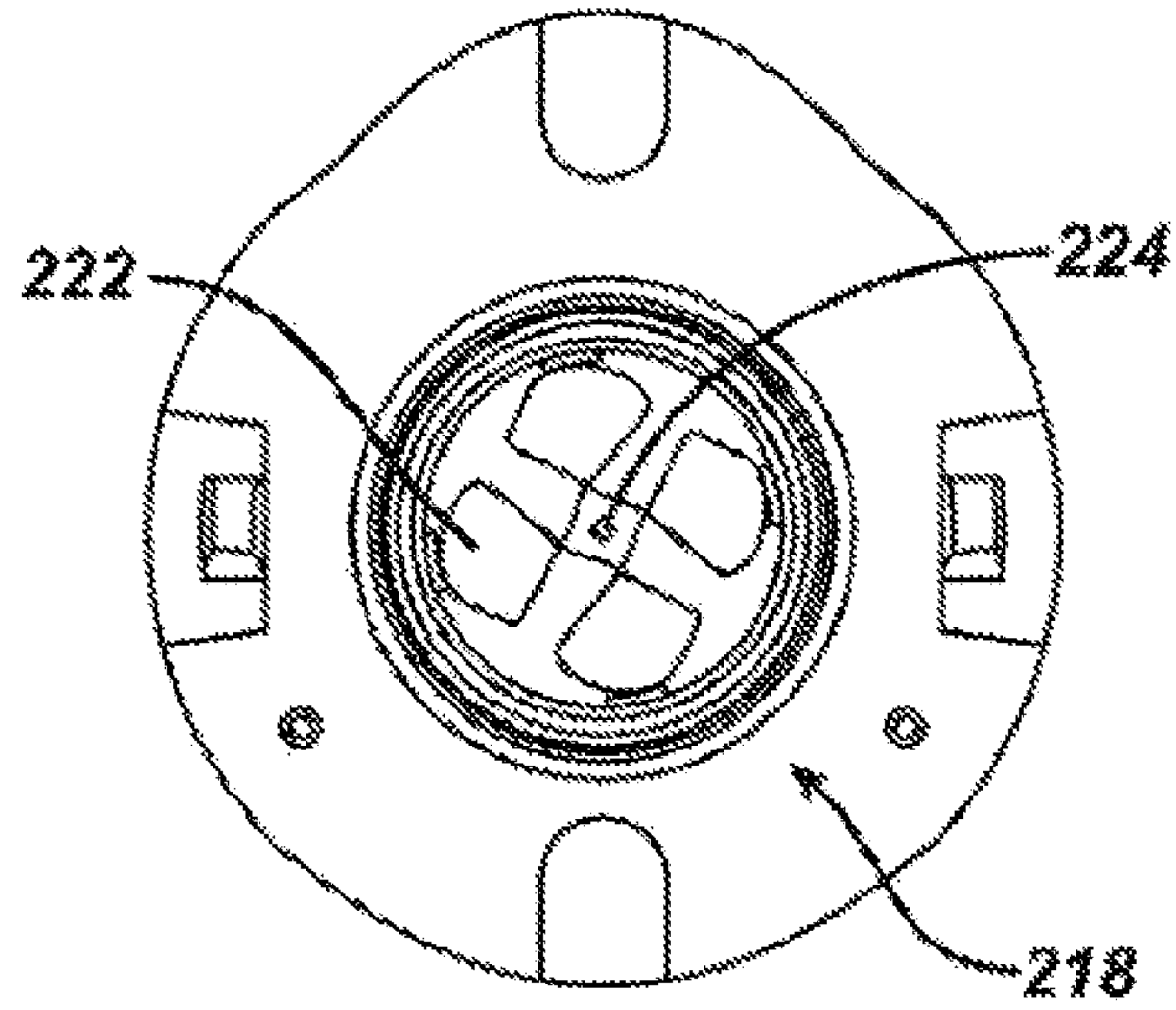


**FIG. 14**

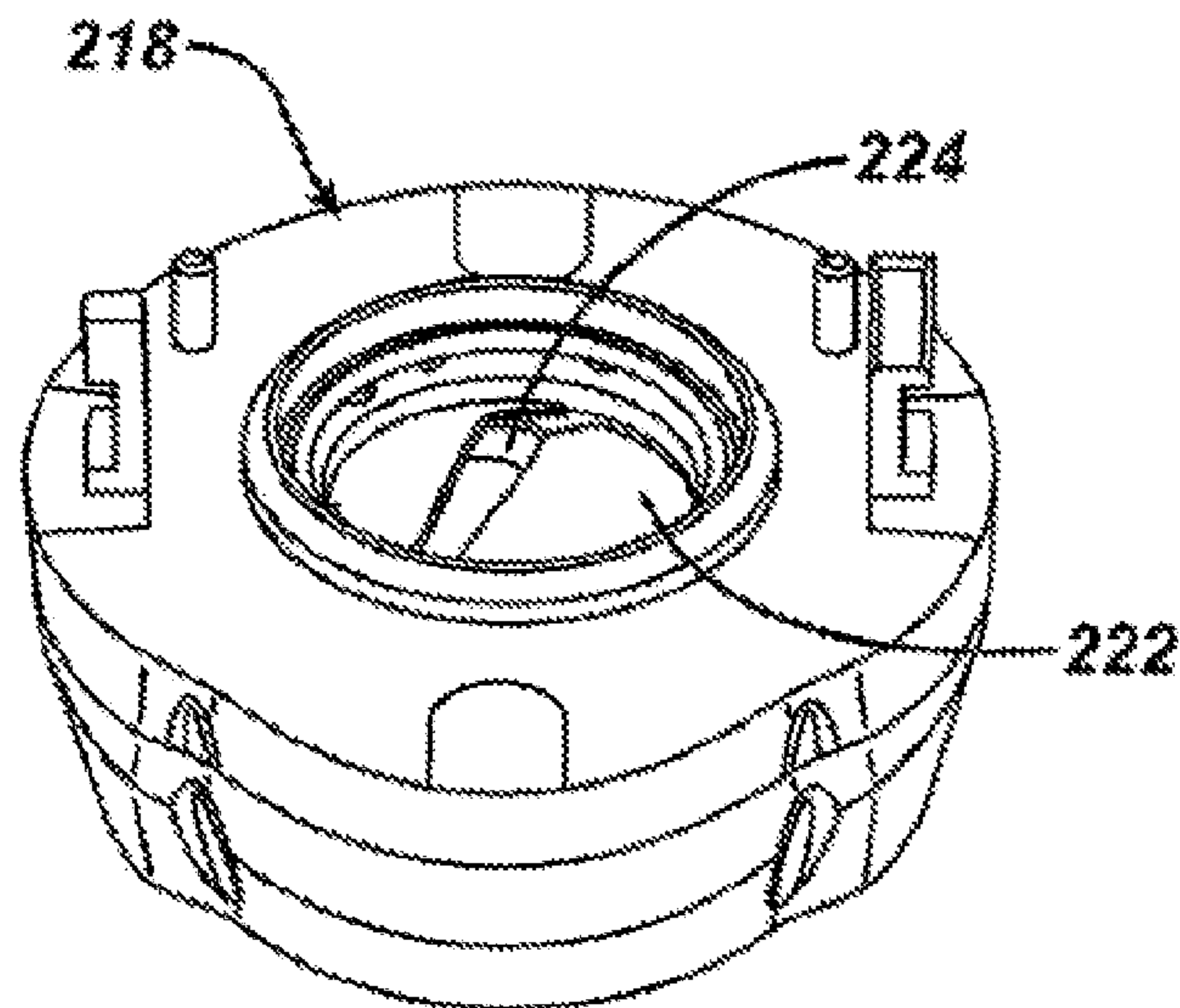




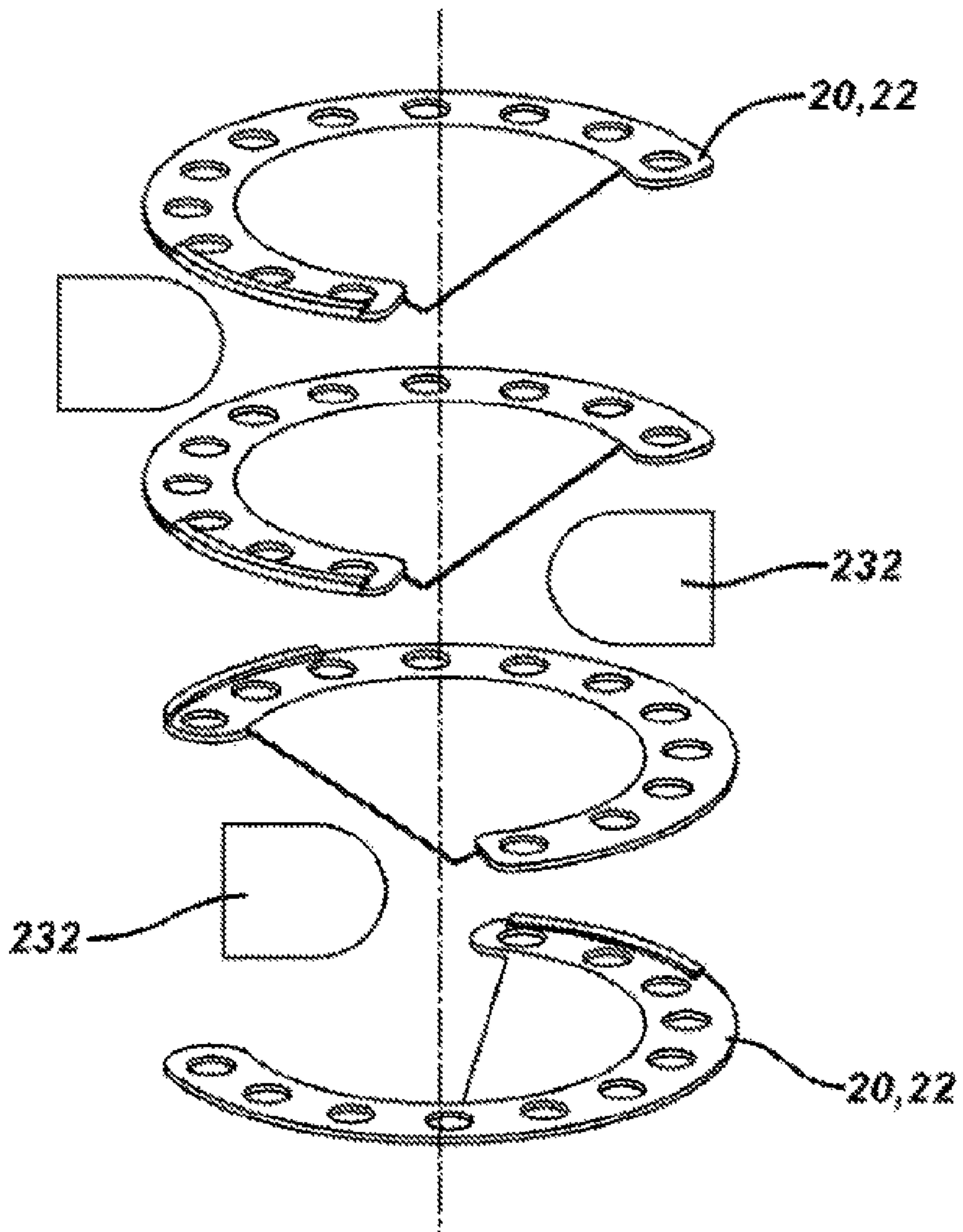
**FIG. 15A**



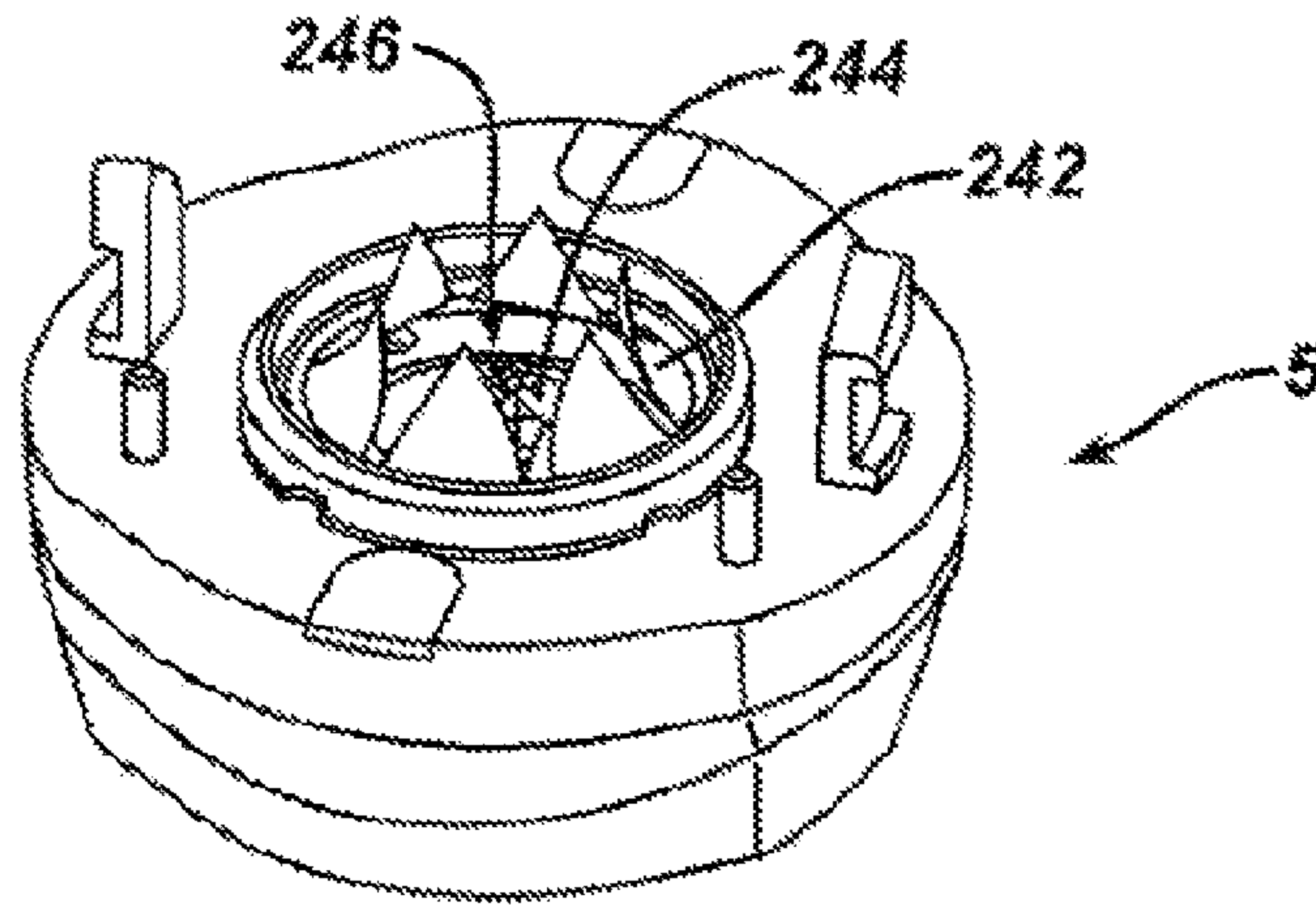
**FIG. 15B**



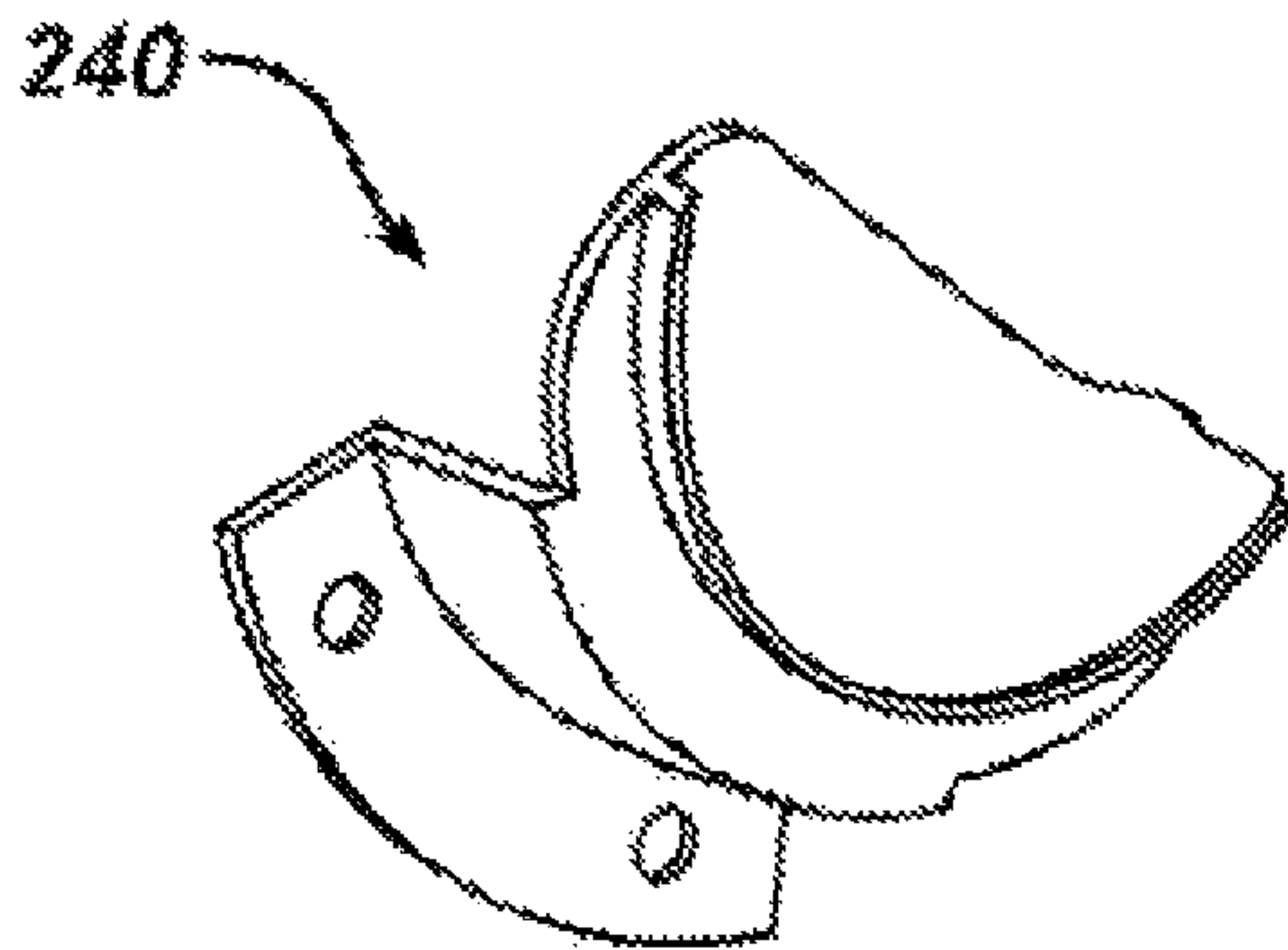
**FIG. 16**



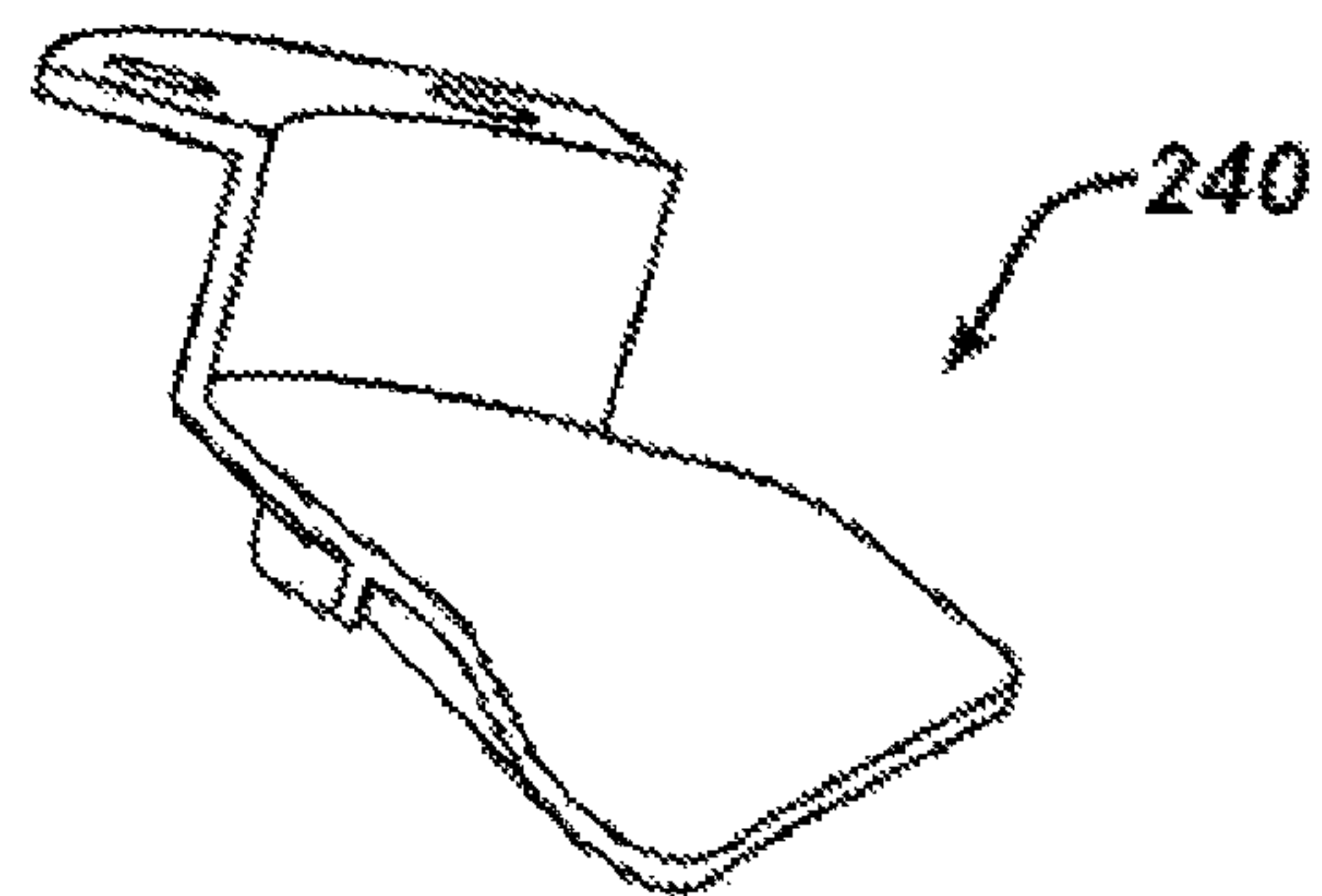
**FIG. 17**



**FIG. 18A**

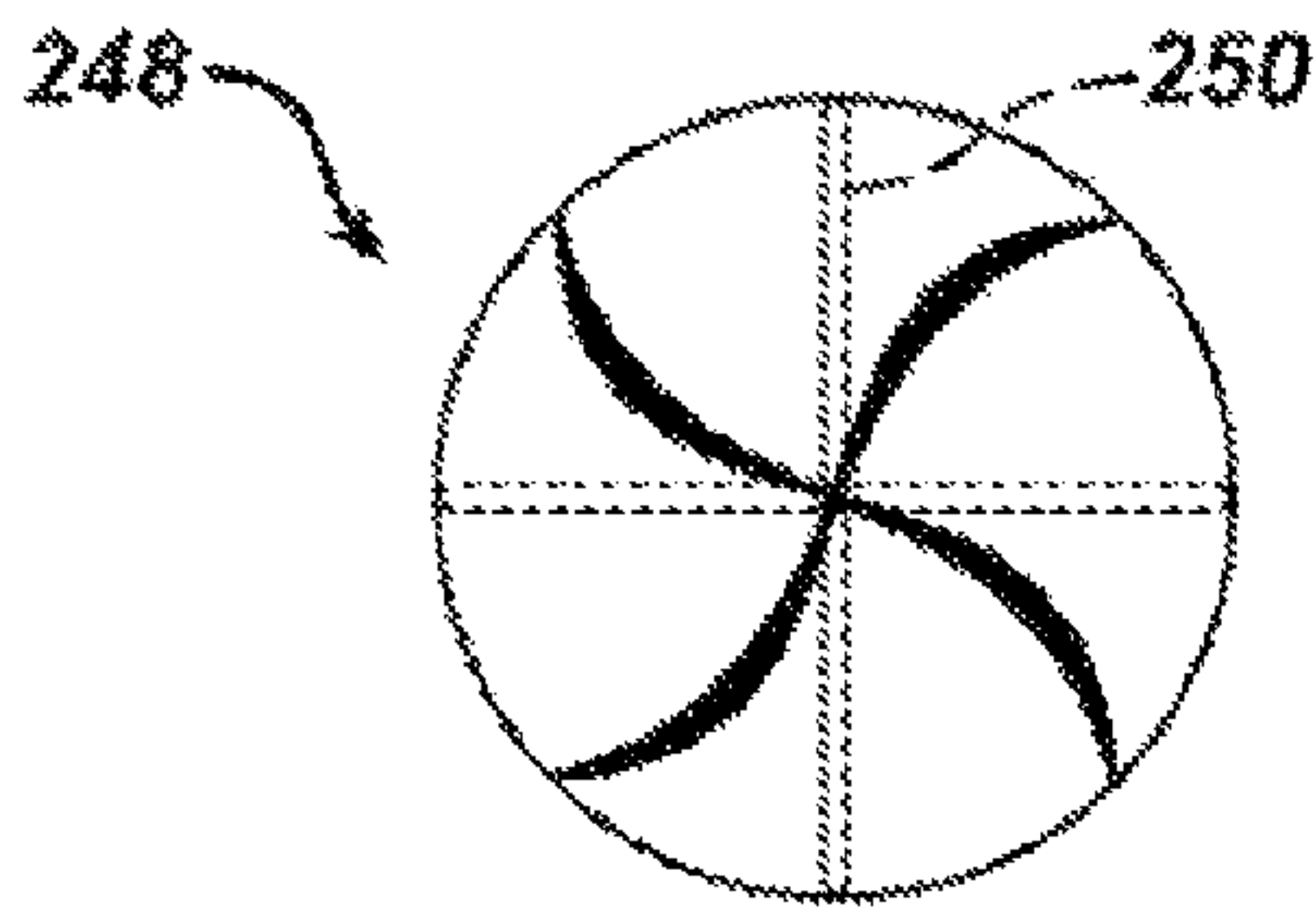


**FIG. 18B**

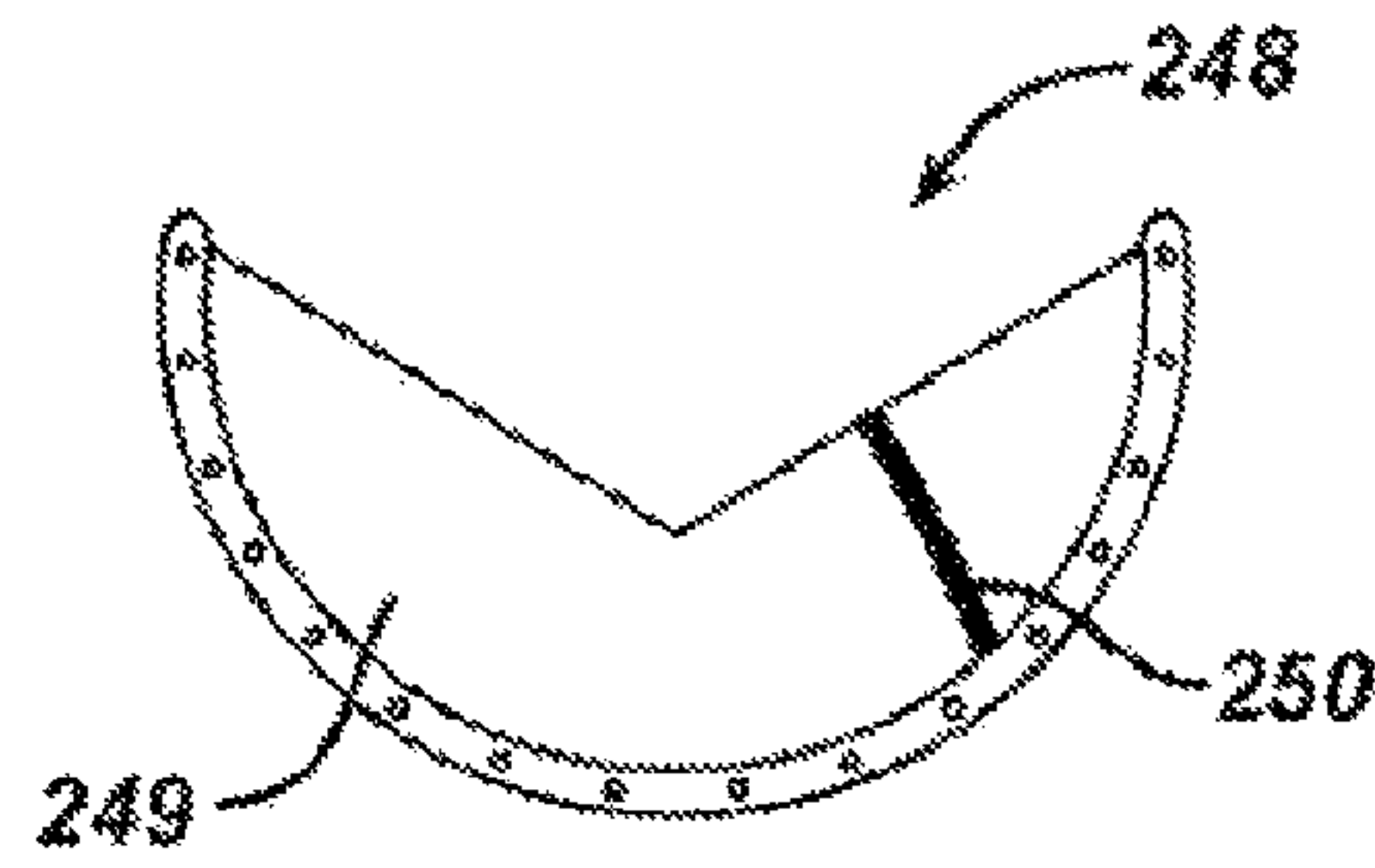




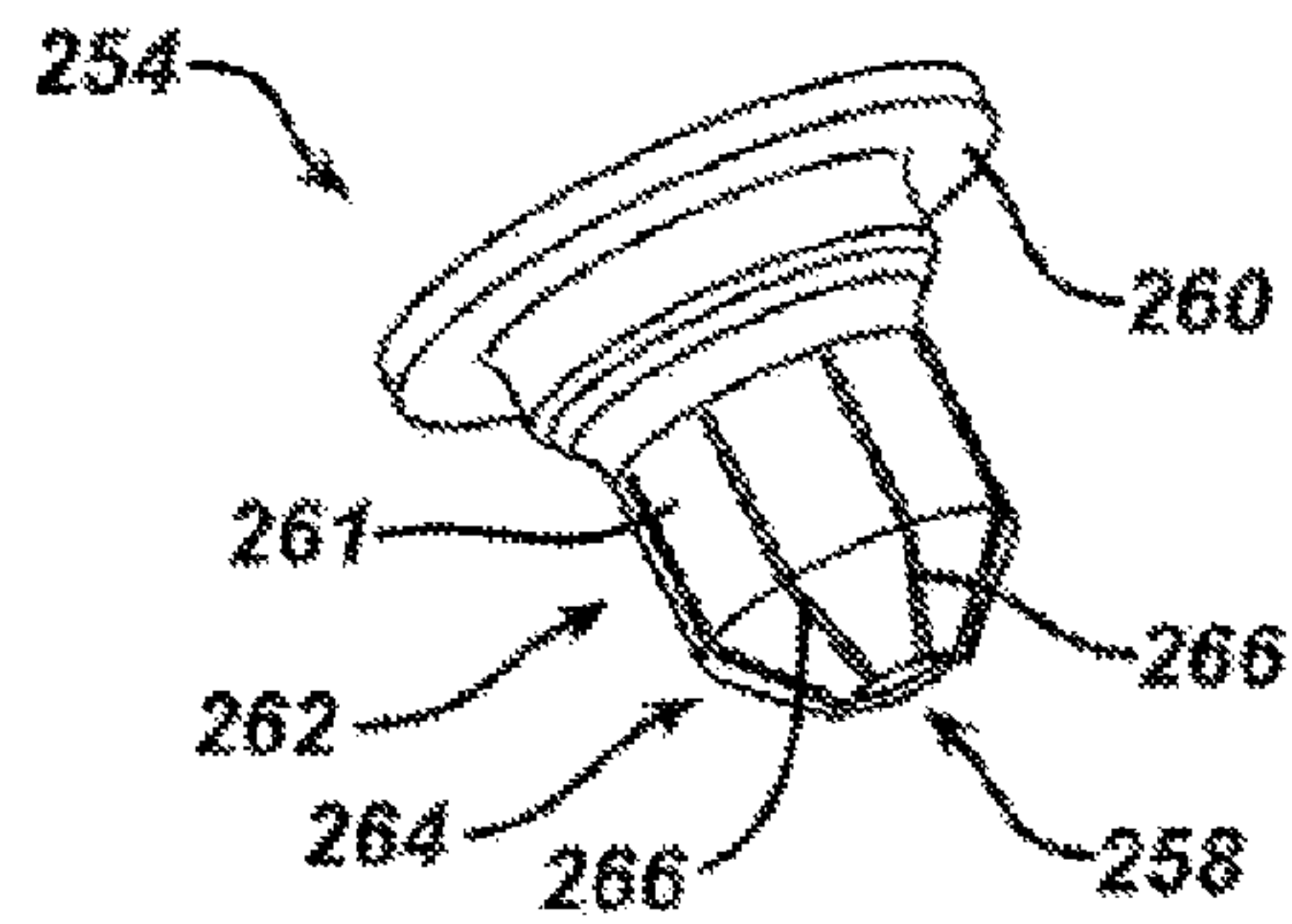
**FIG. 19A**



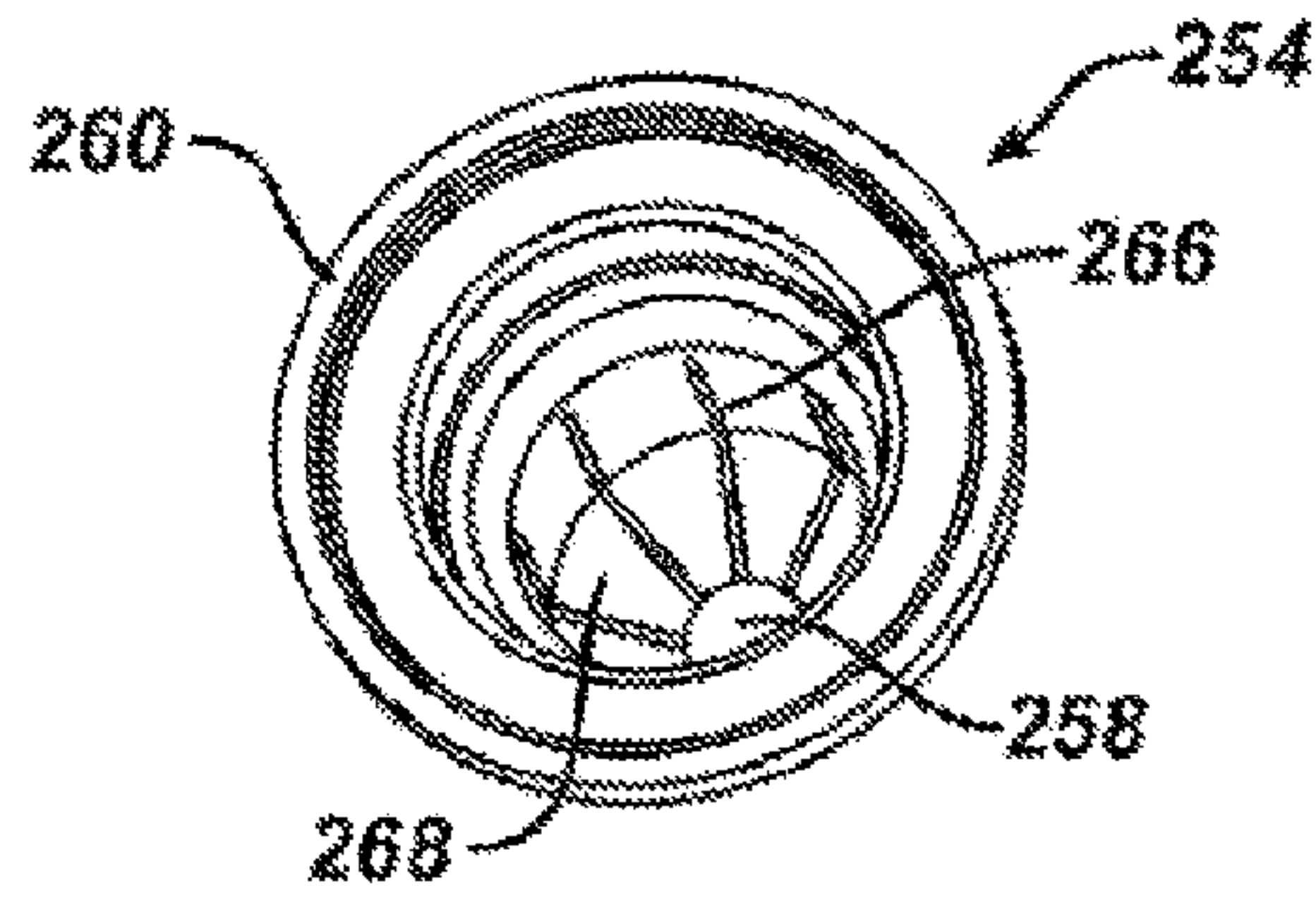
**FIG. 19B**



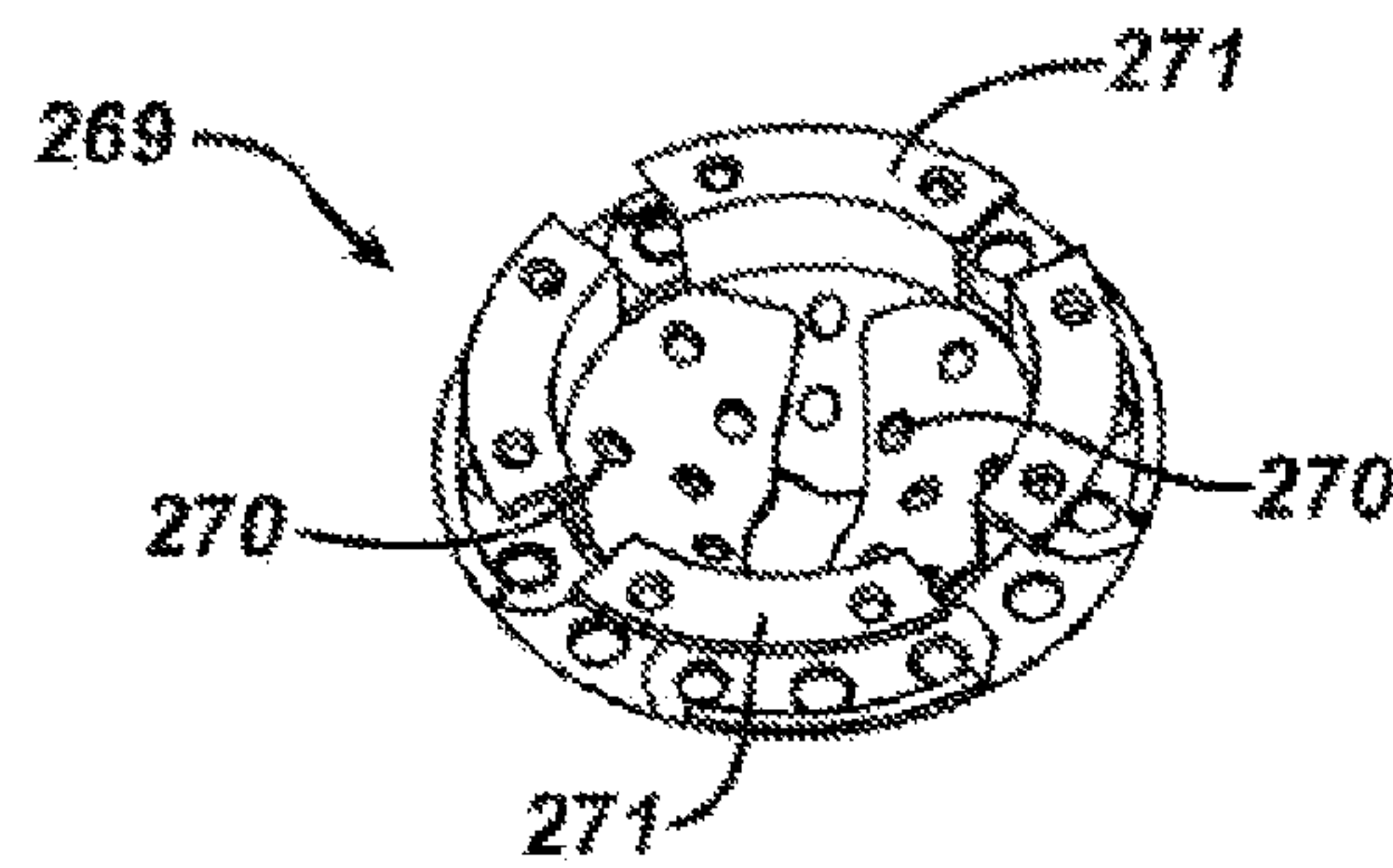
**FIG. 20A**



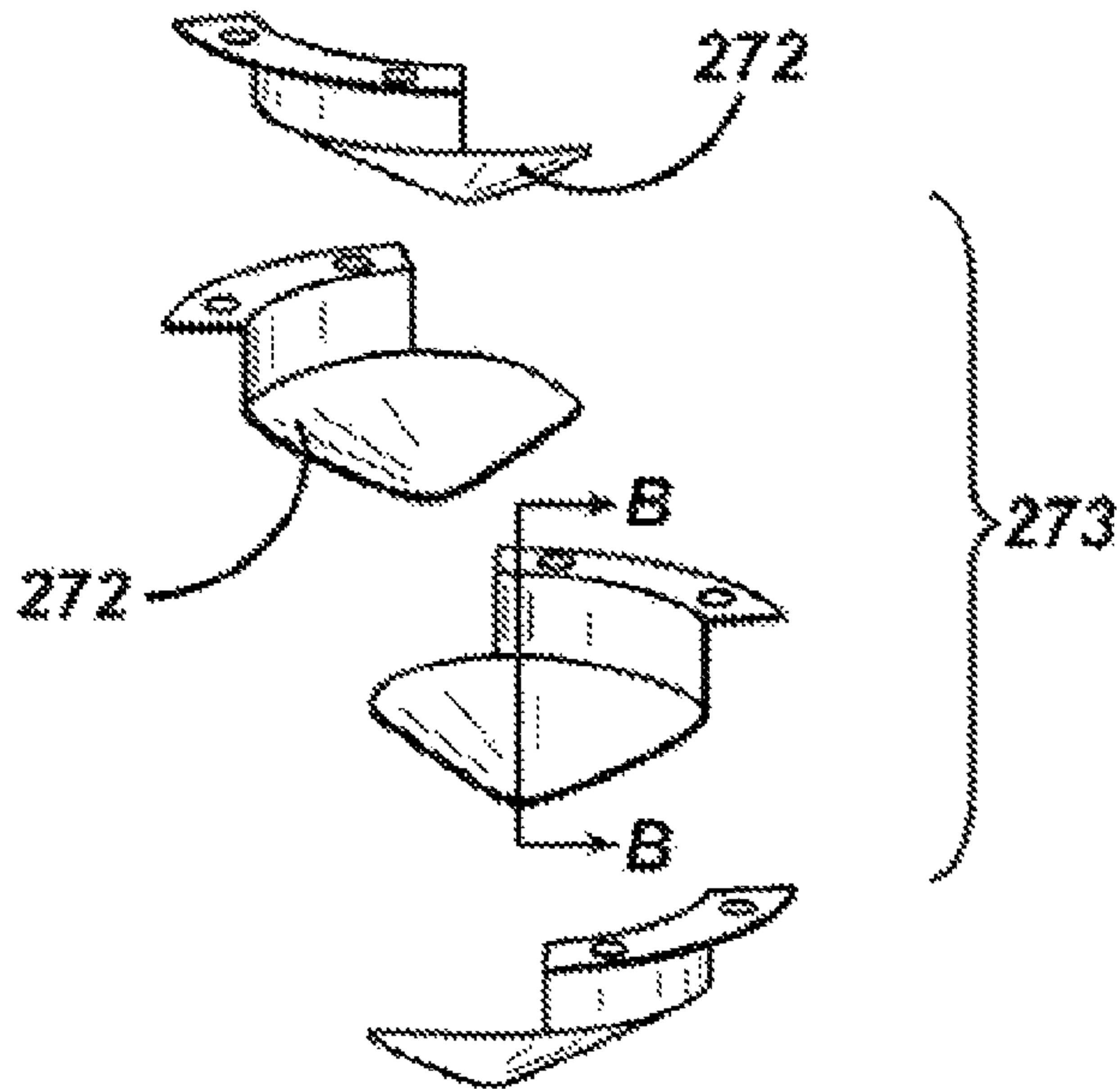
**FIG. 20B**



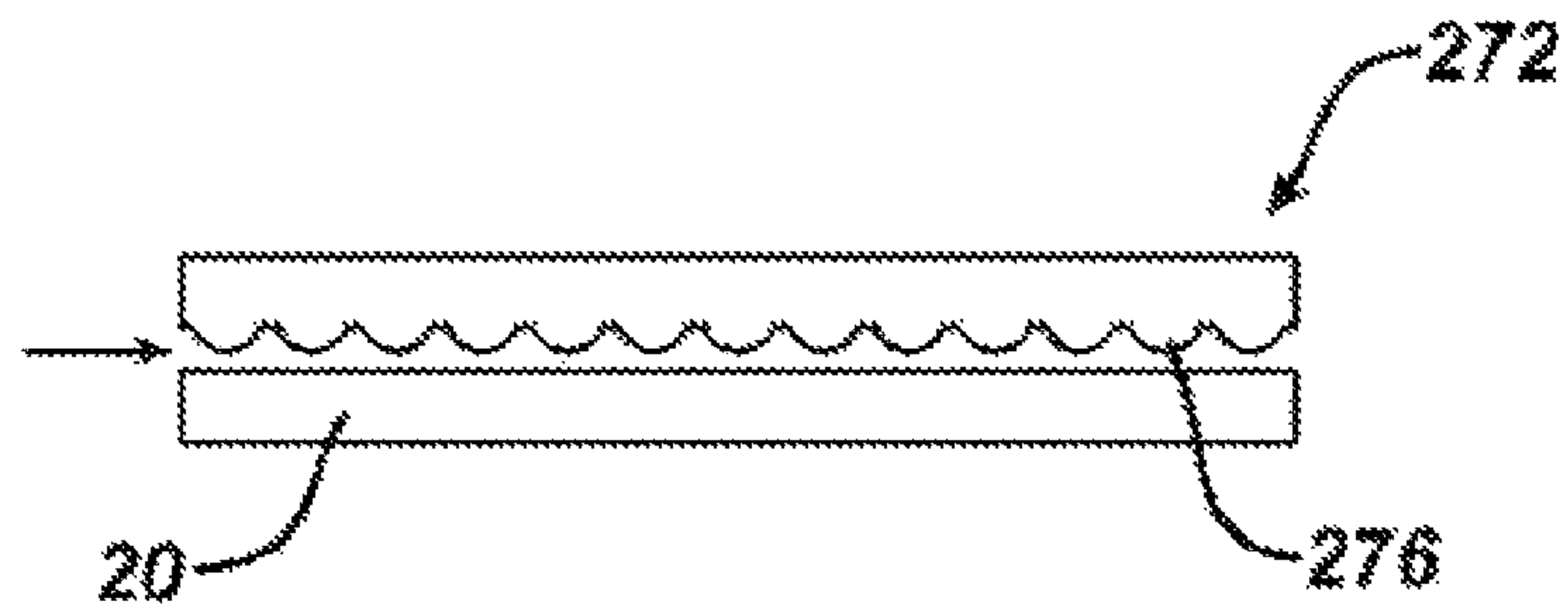
**FIG. 21**



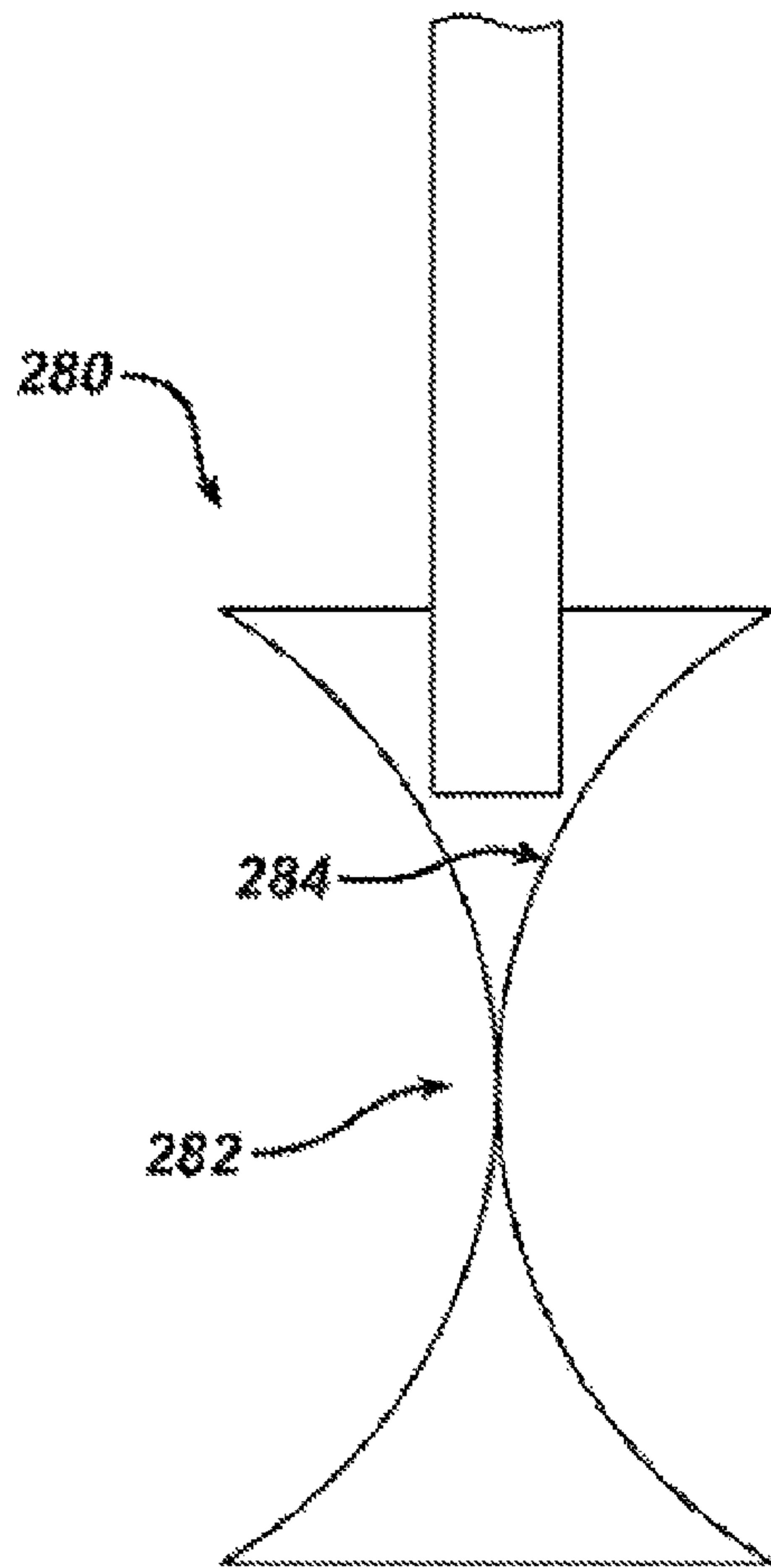
**FIG. 22A**



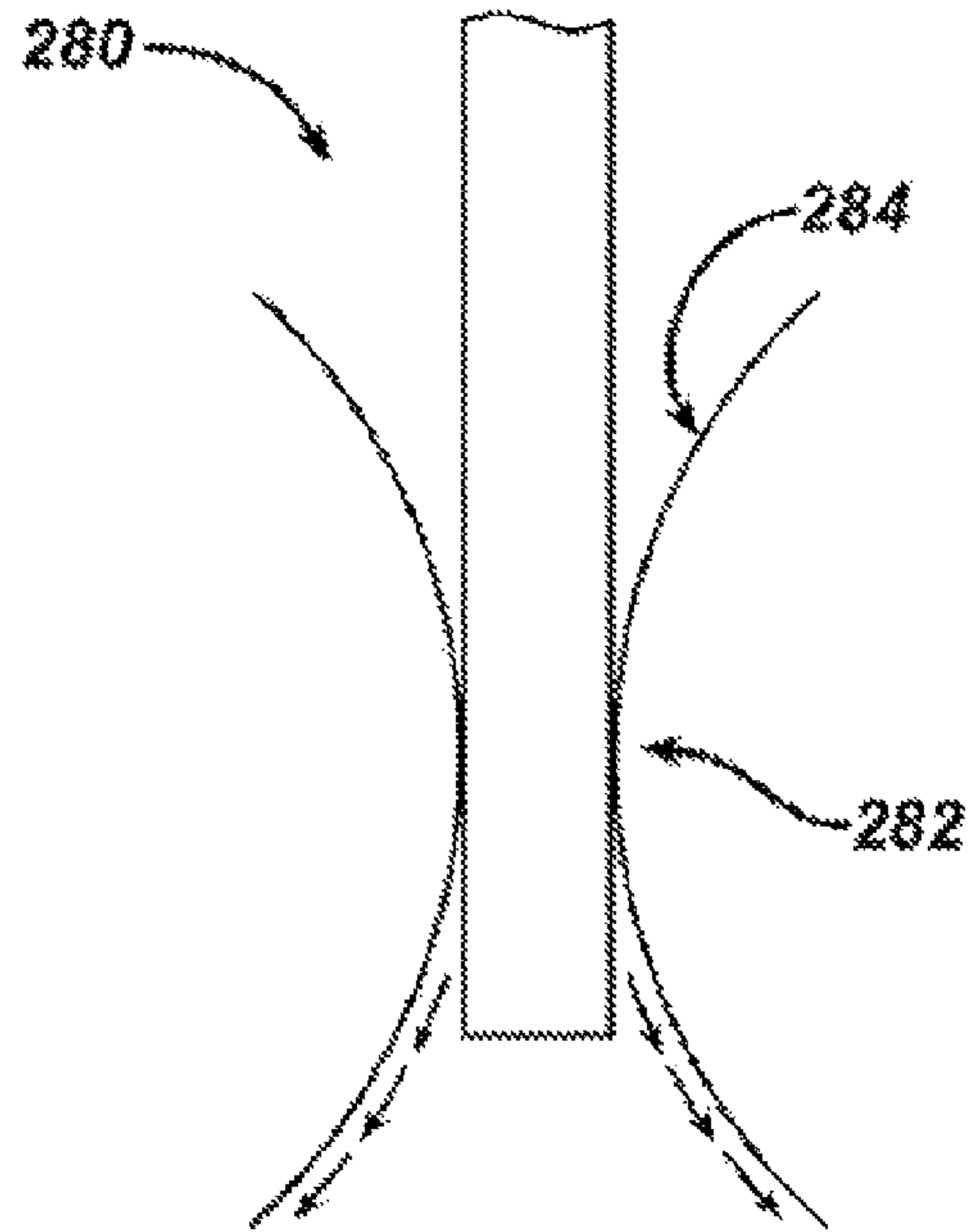
**FIG. 22B**



**FIG. 23A**

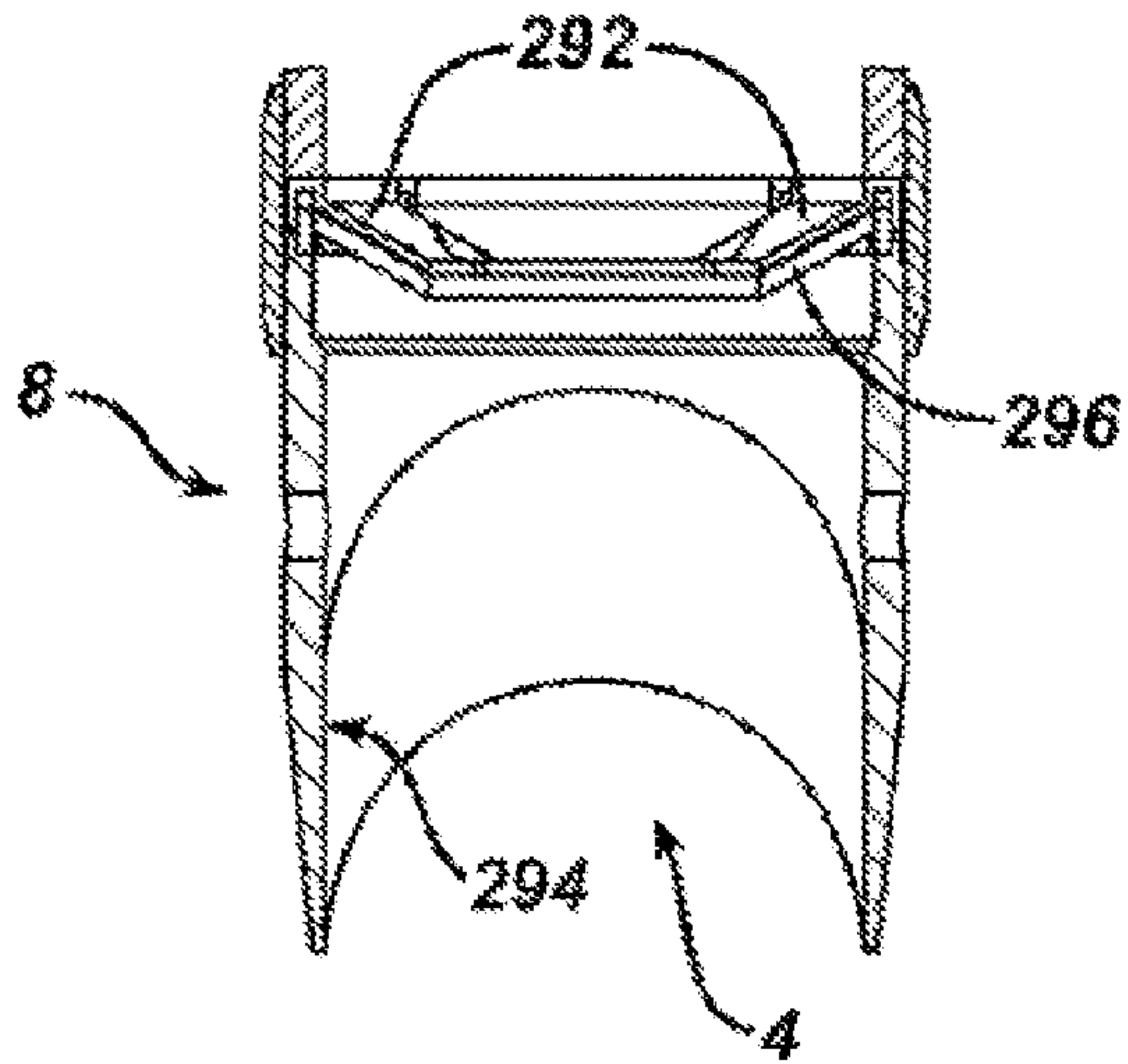


**FIG. 23B**

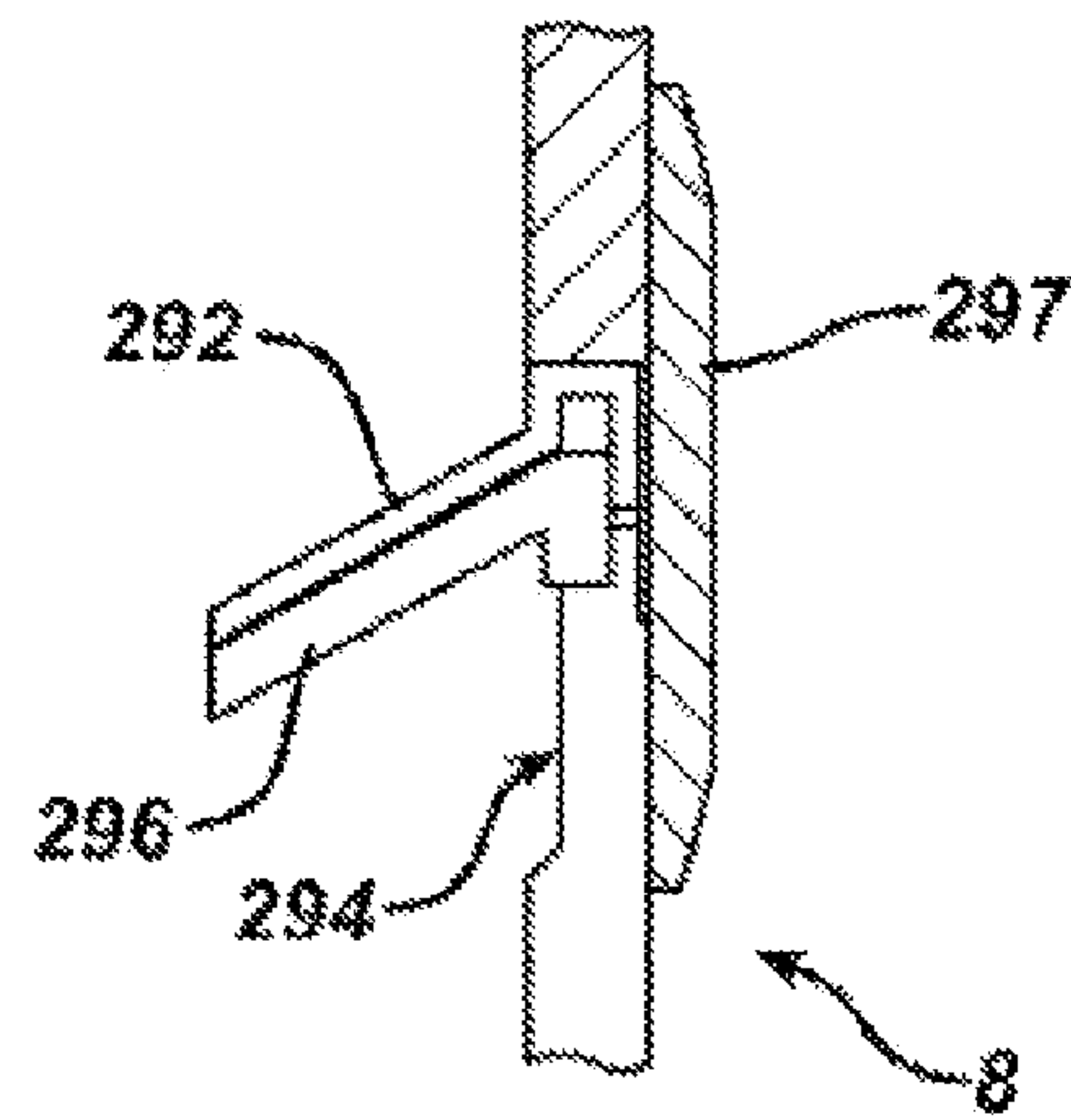




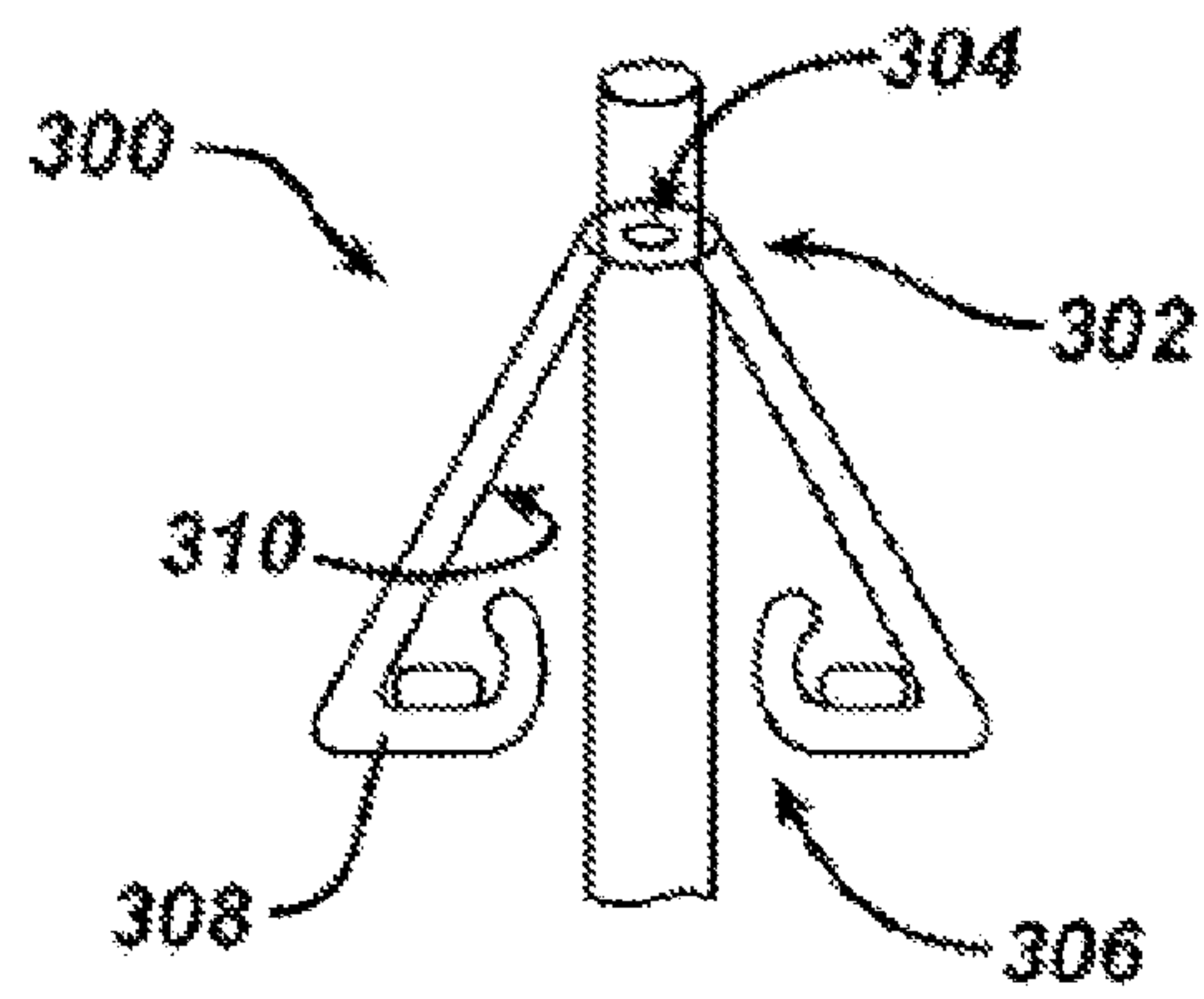
**FIG. 24A**



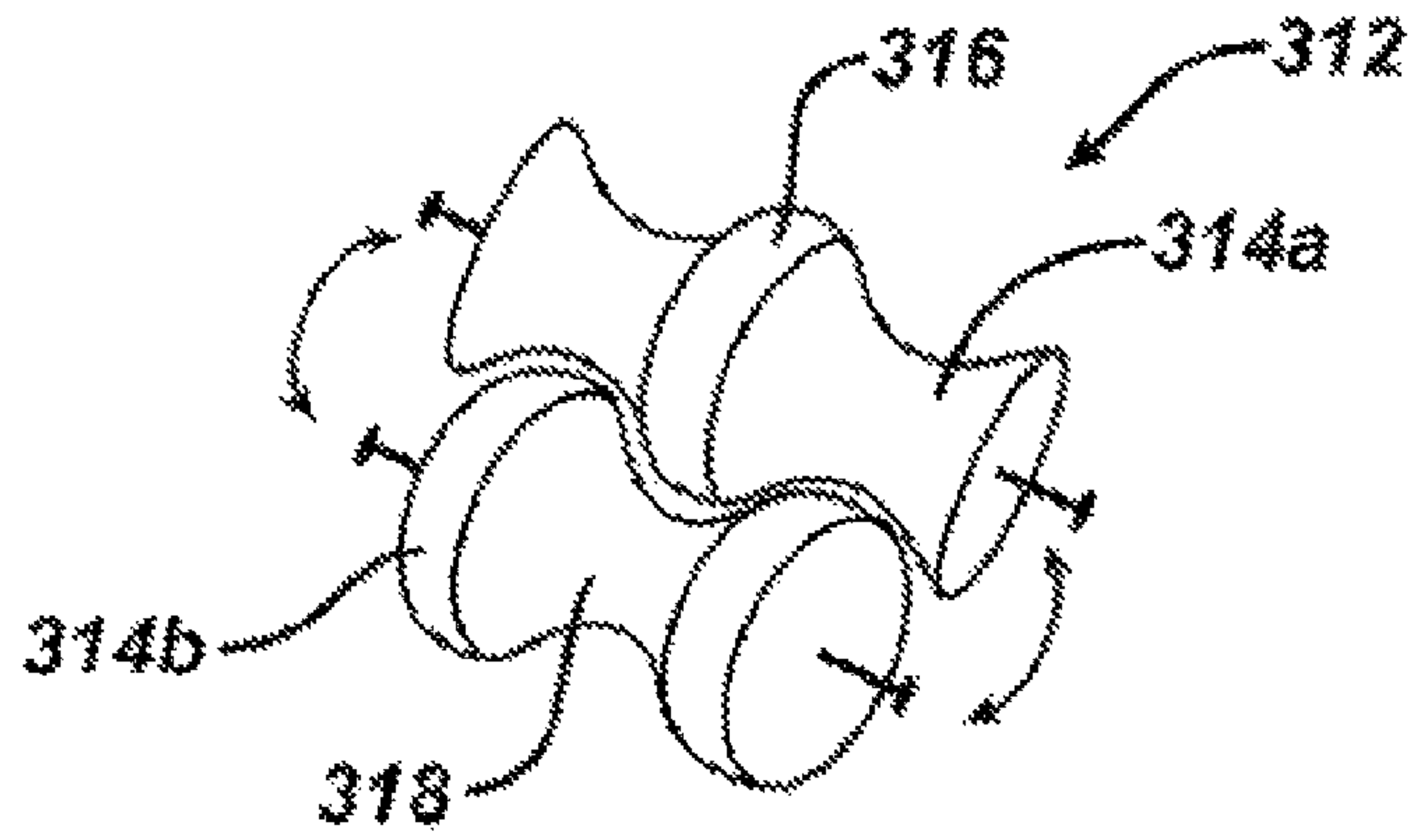
**FIG. 24B**



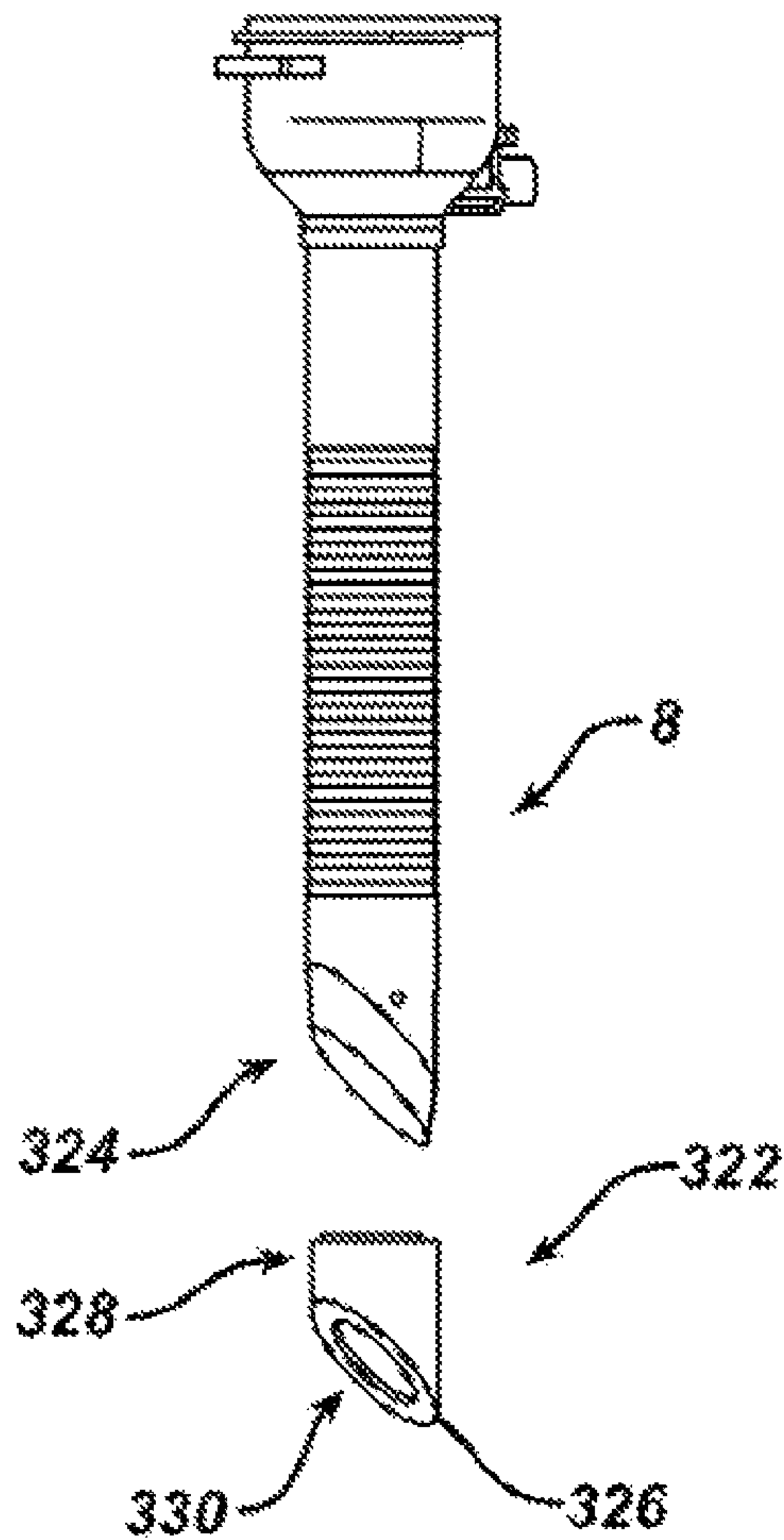
**FIG. 25**



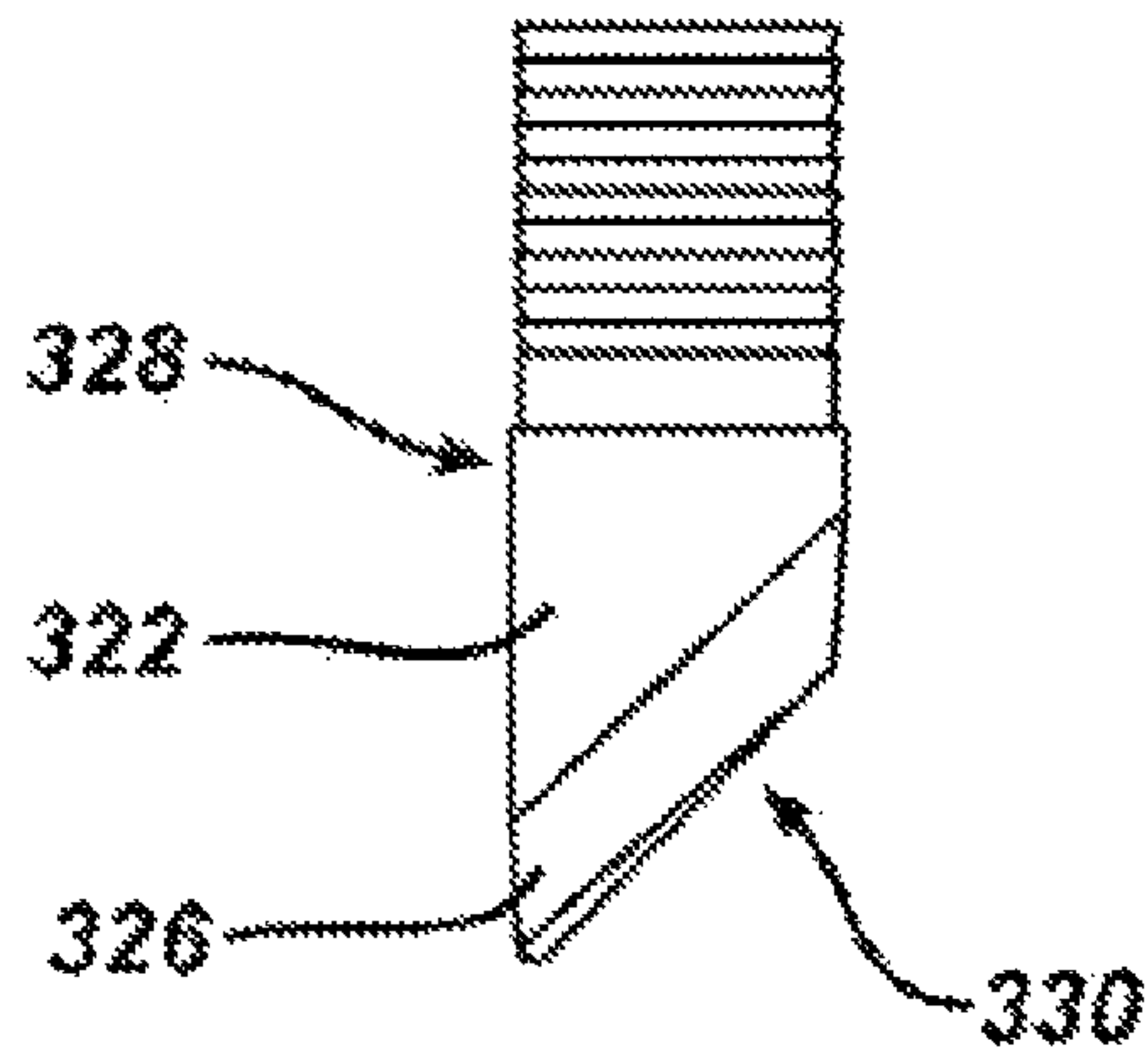
**FIG. 26**



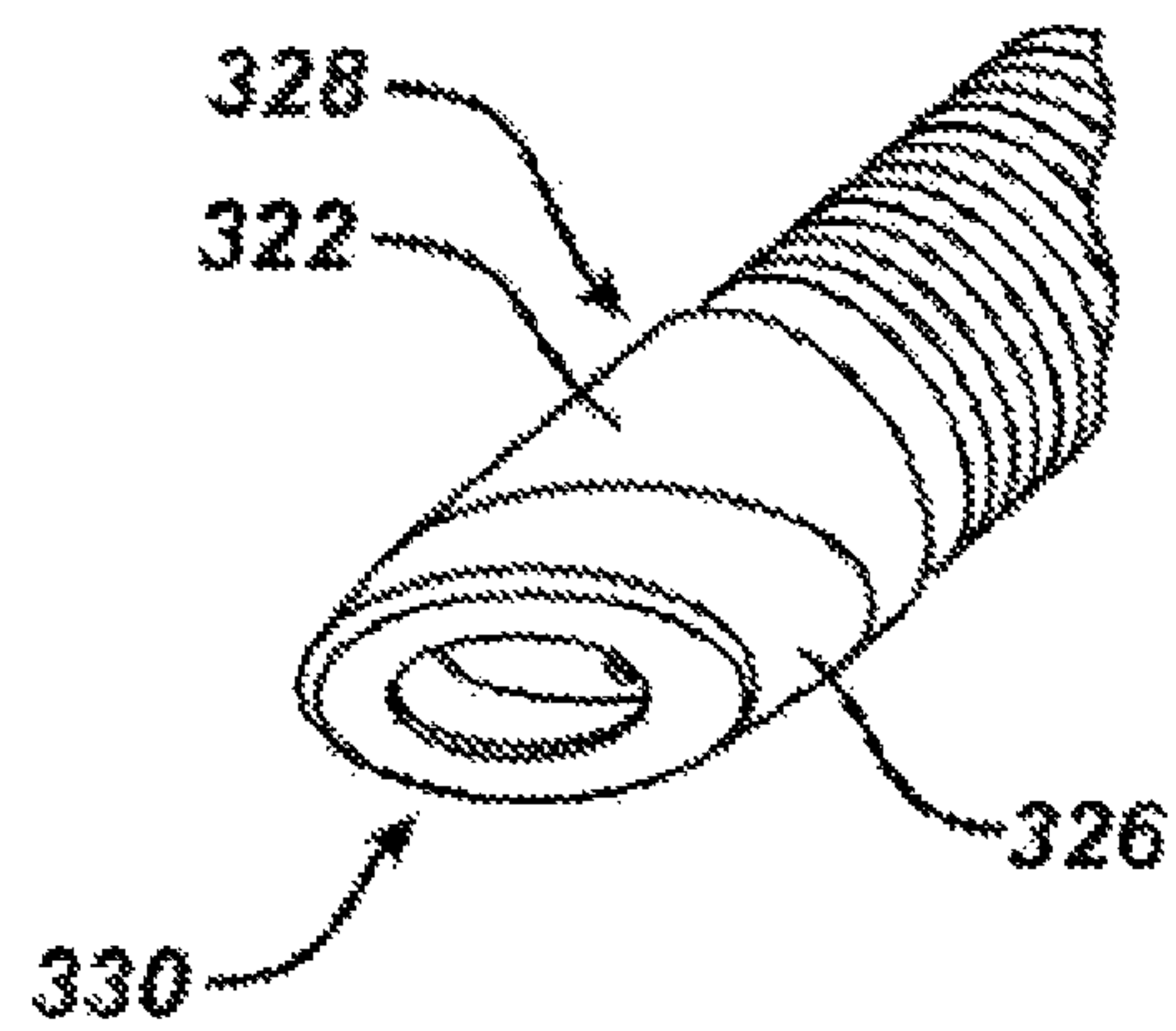
**FIG. 27A**



**FIG. 27B**

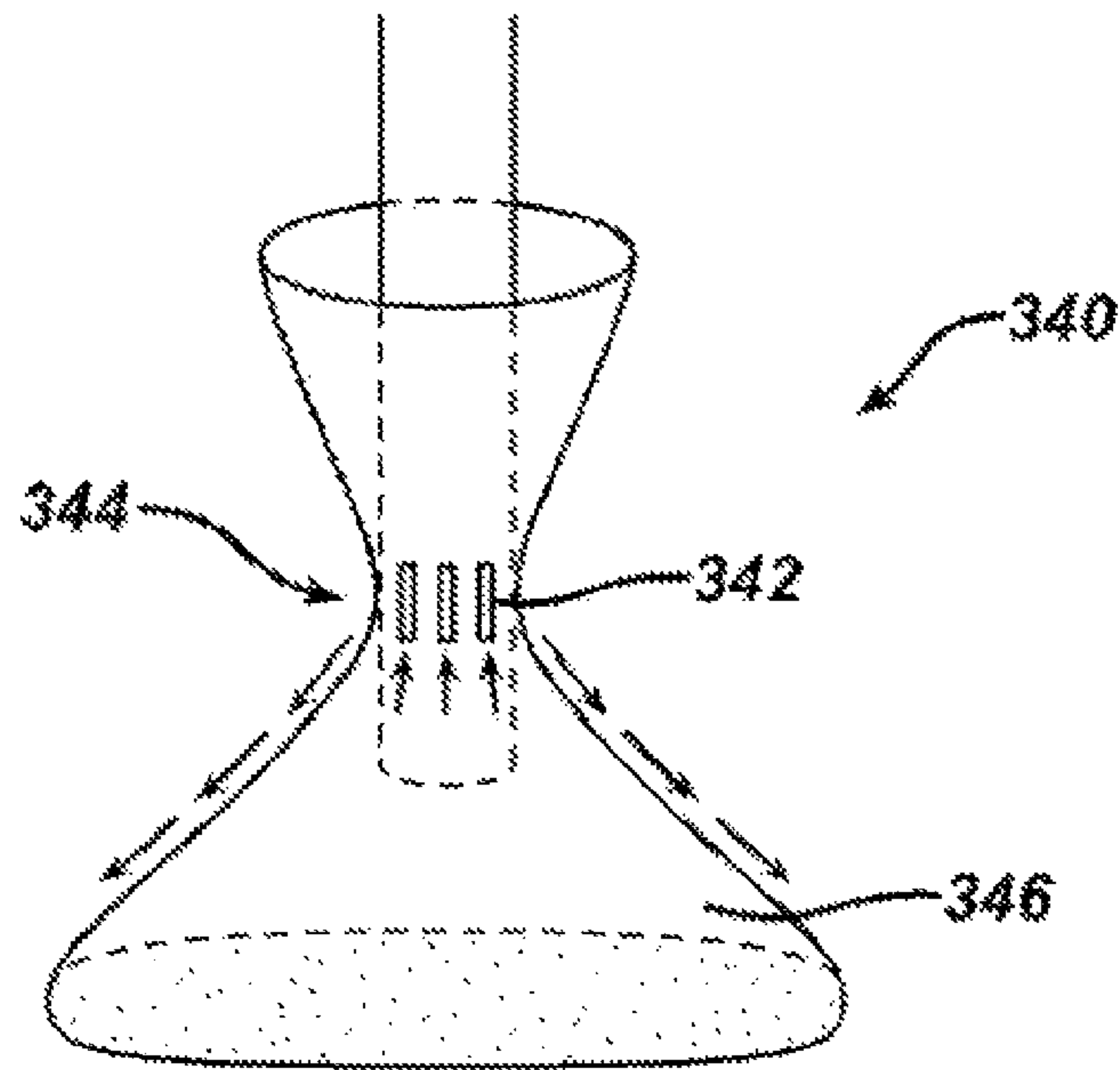


**FIG. 27C**





**FIG. 28**



**FIG. 29**

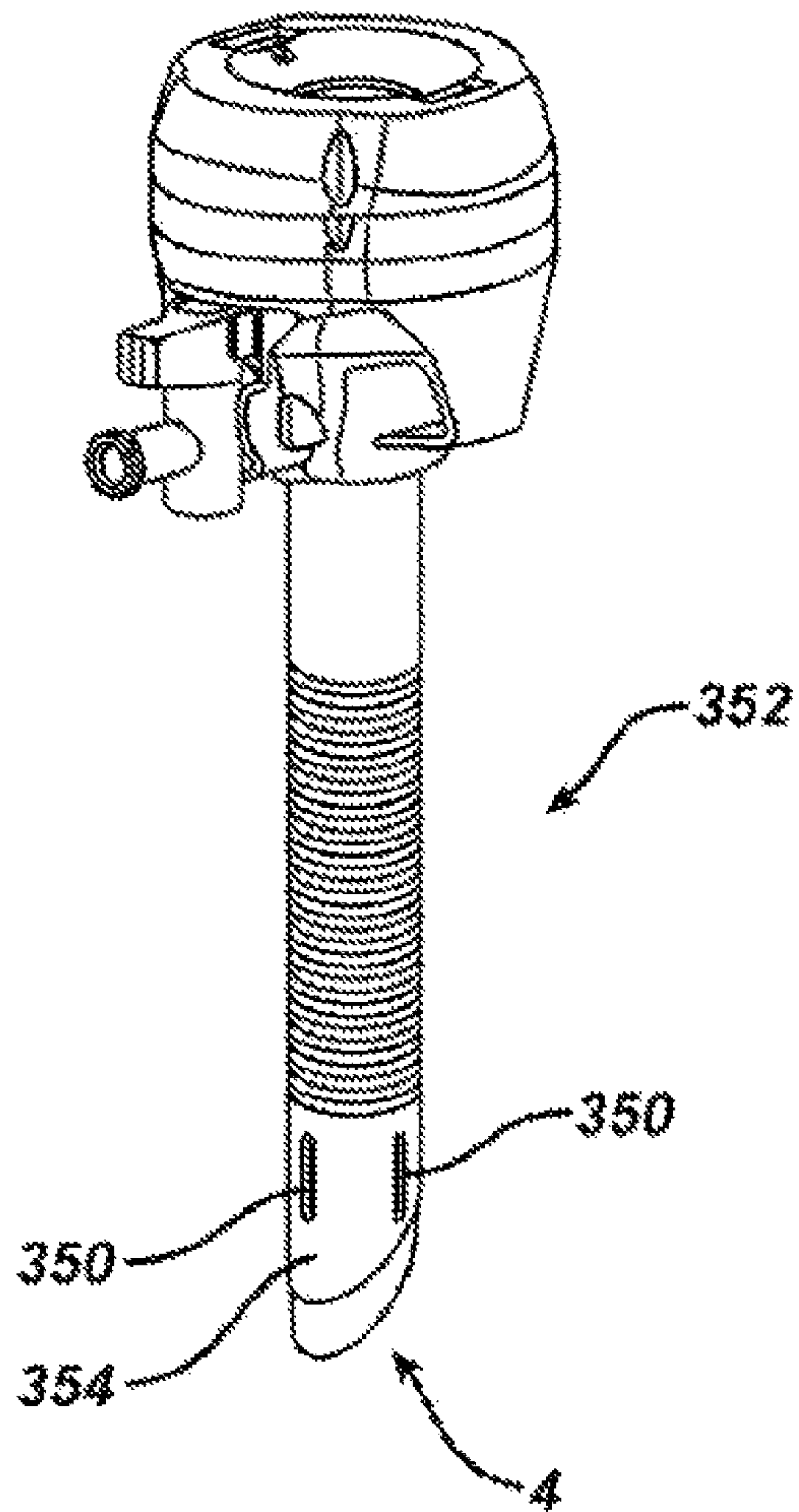


FIG. 30B

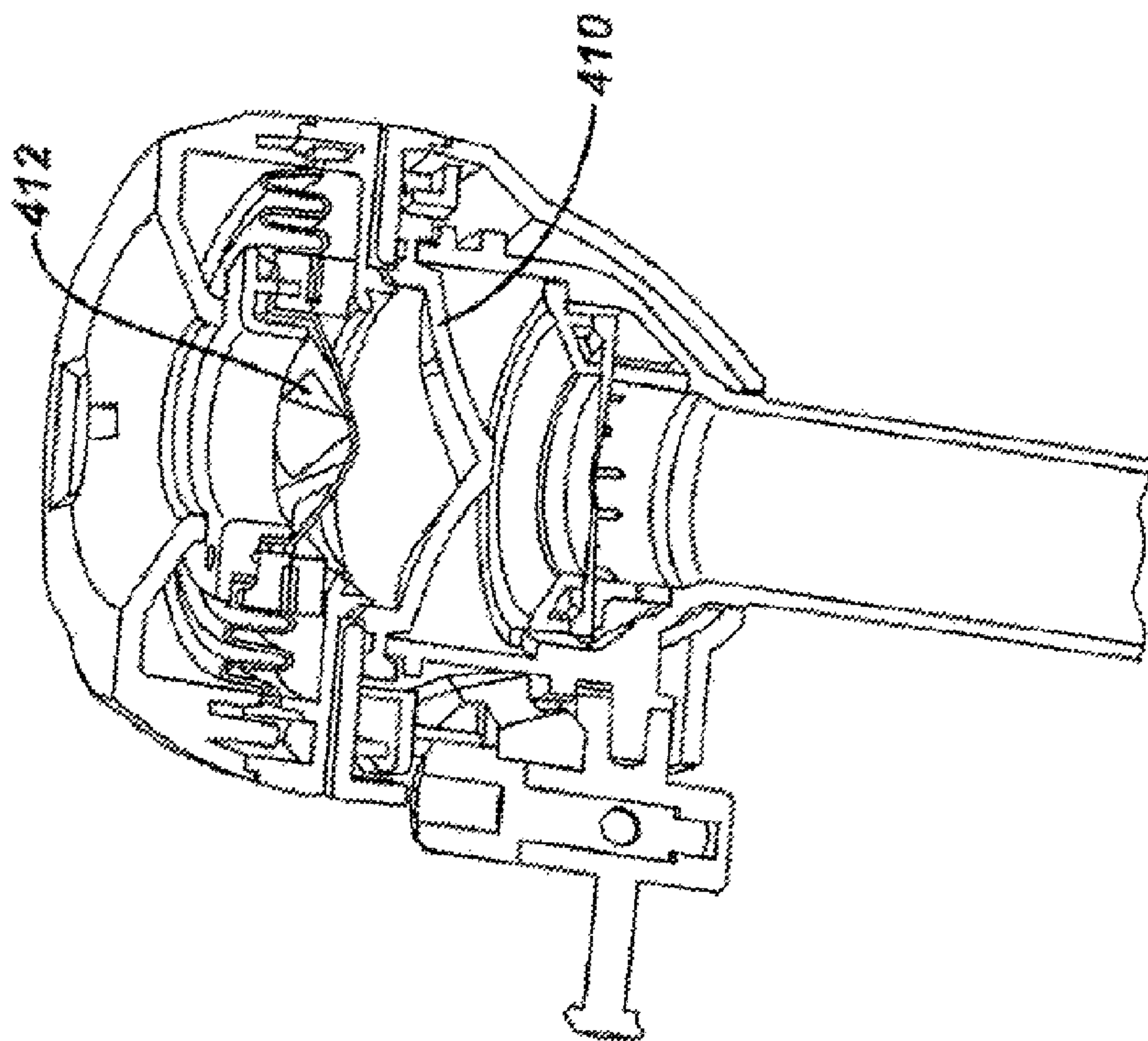


FIG. 30A

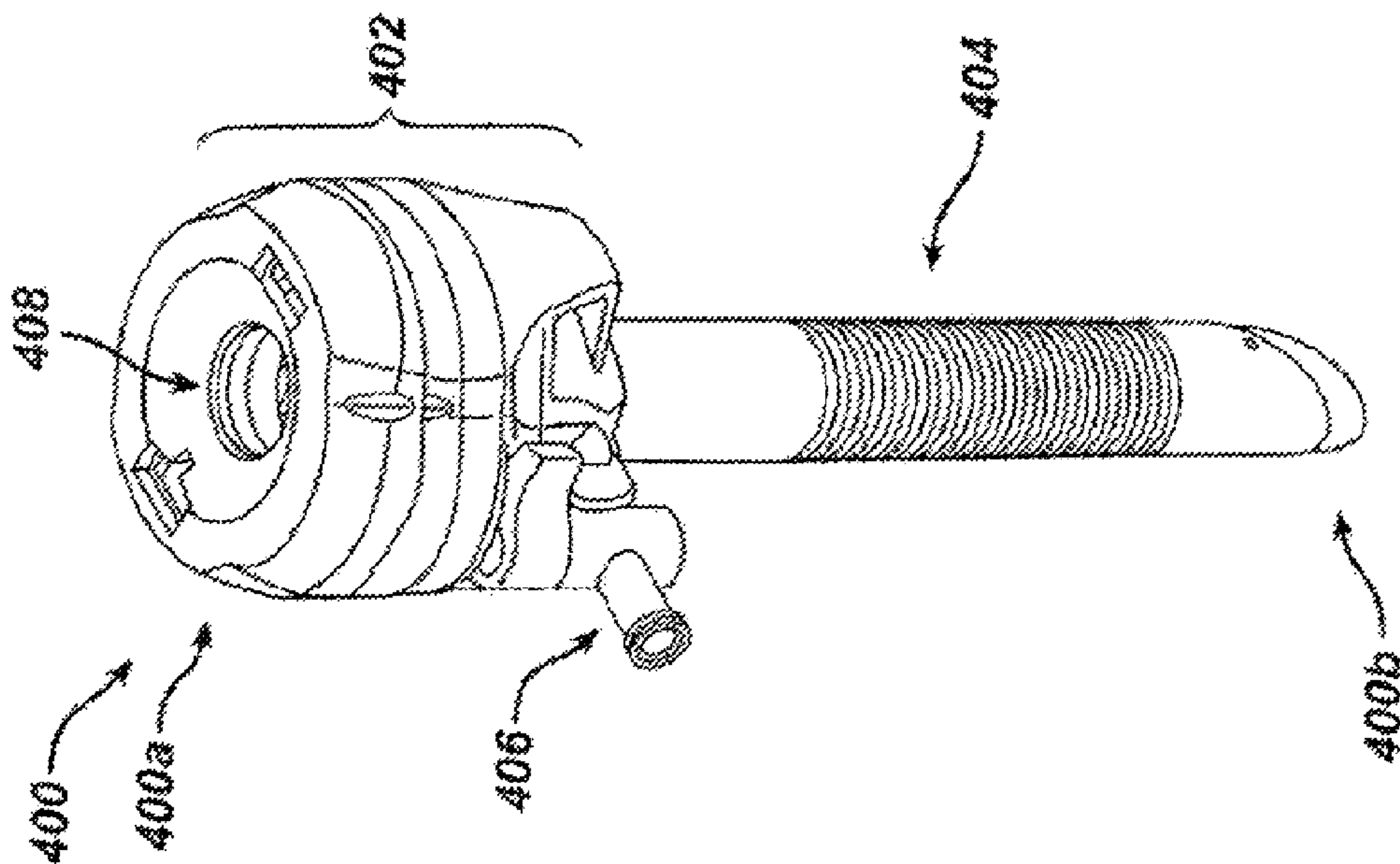




FIG. 30C

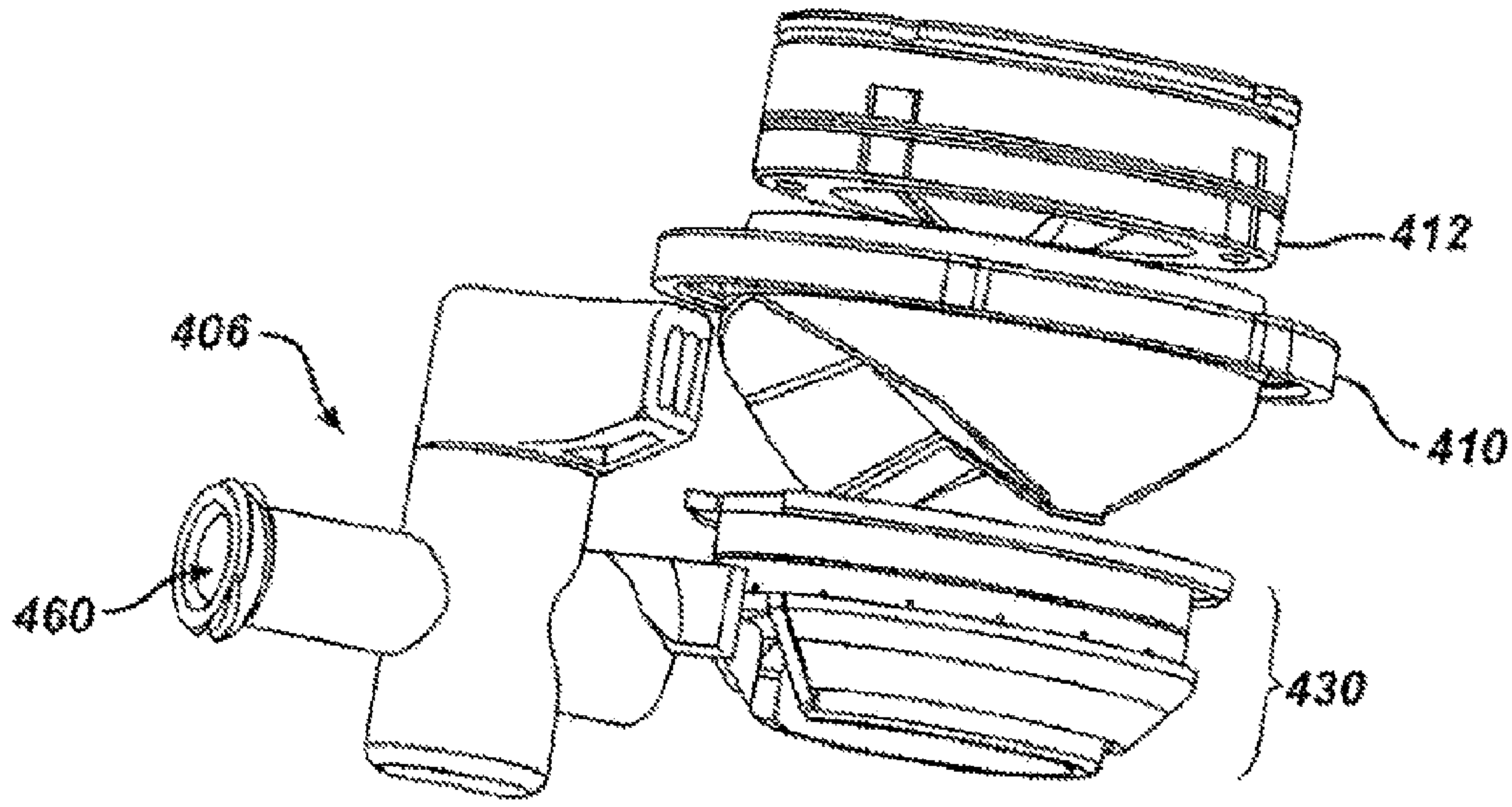


FIG. 30D

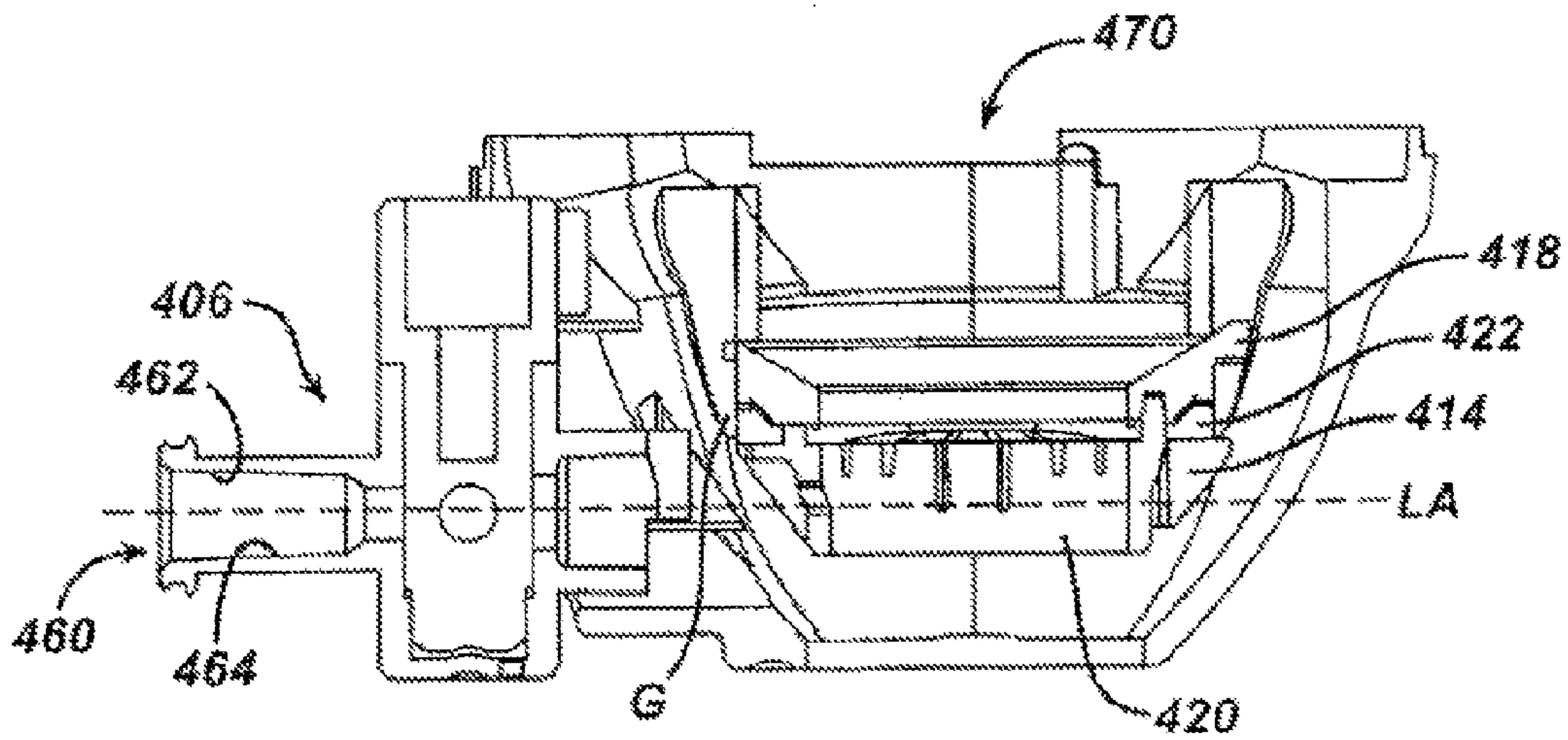


FIG. 30E

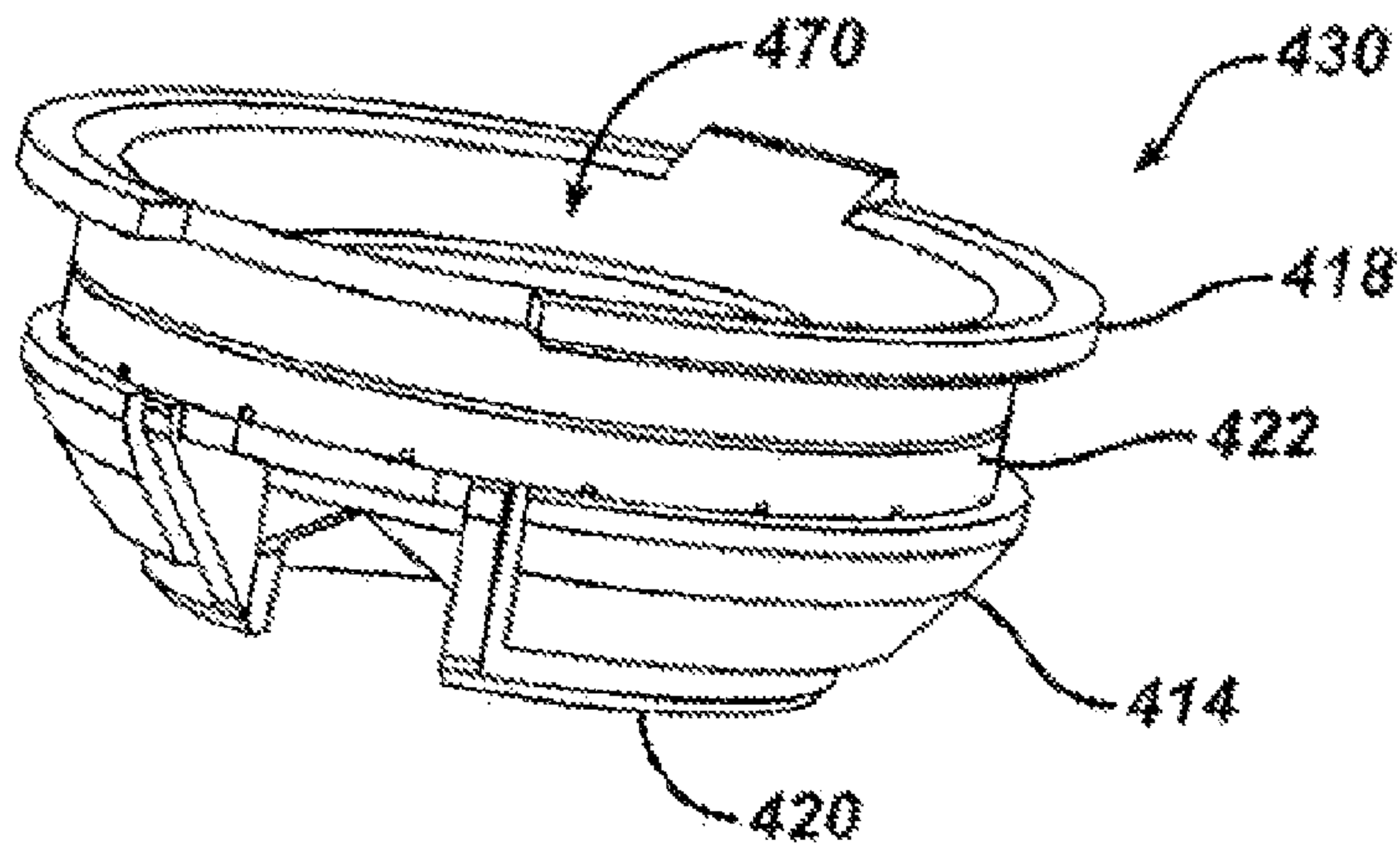
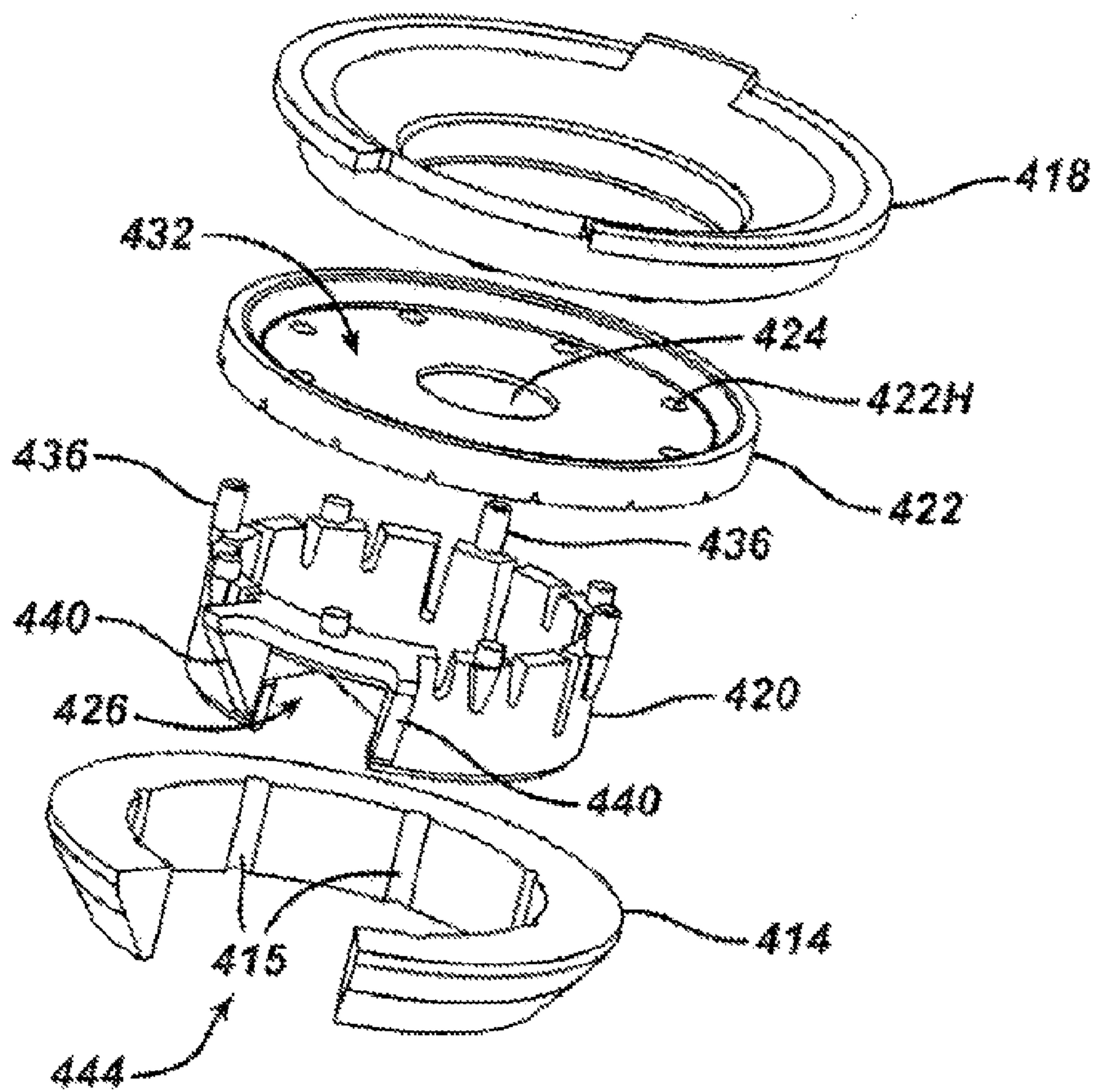
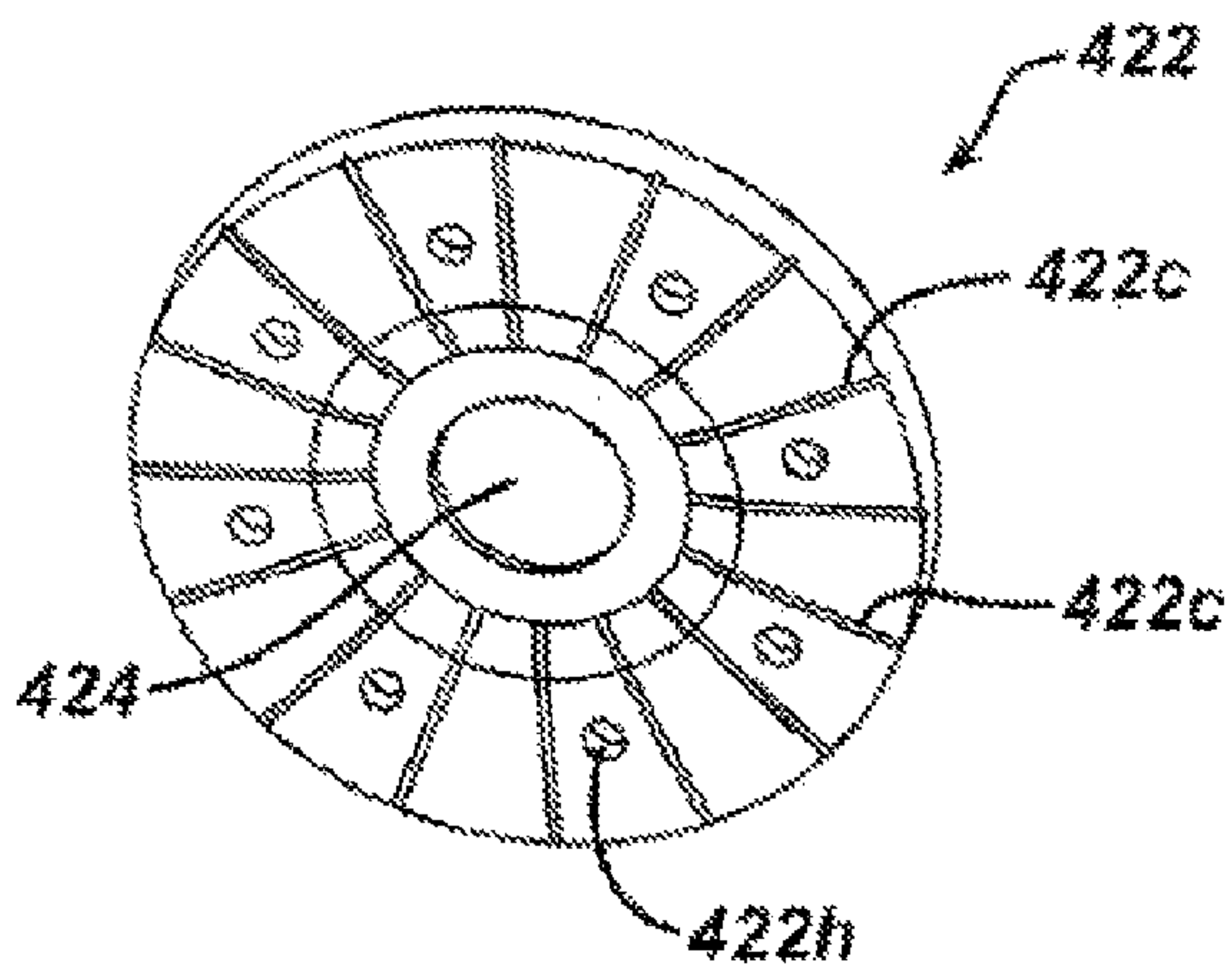


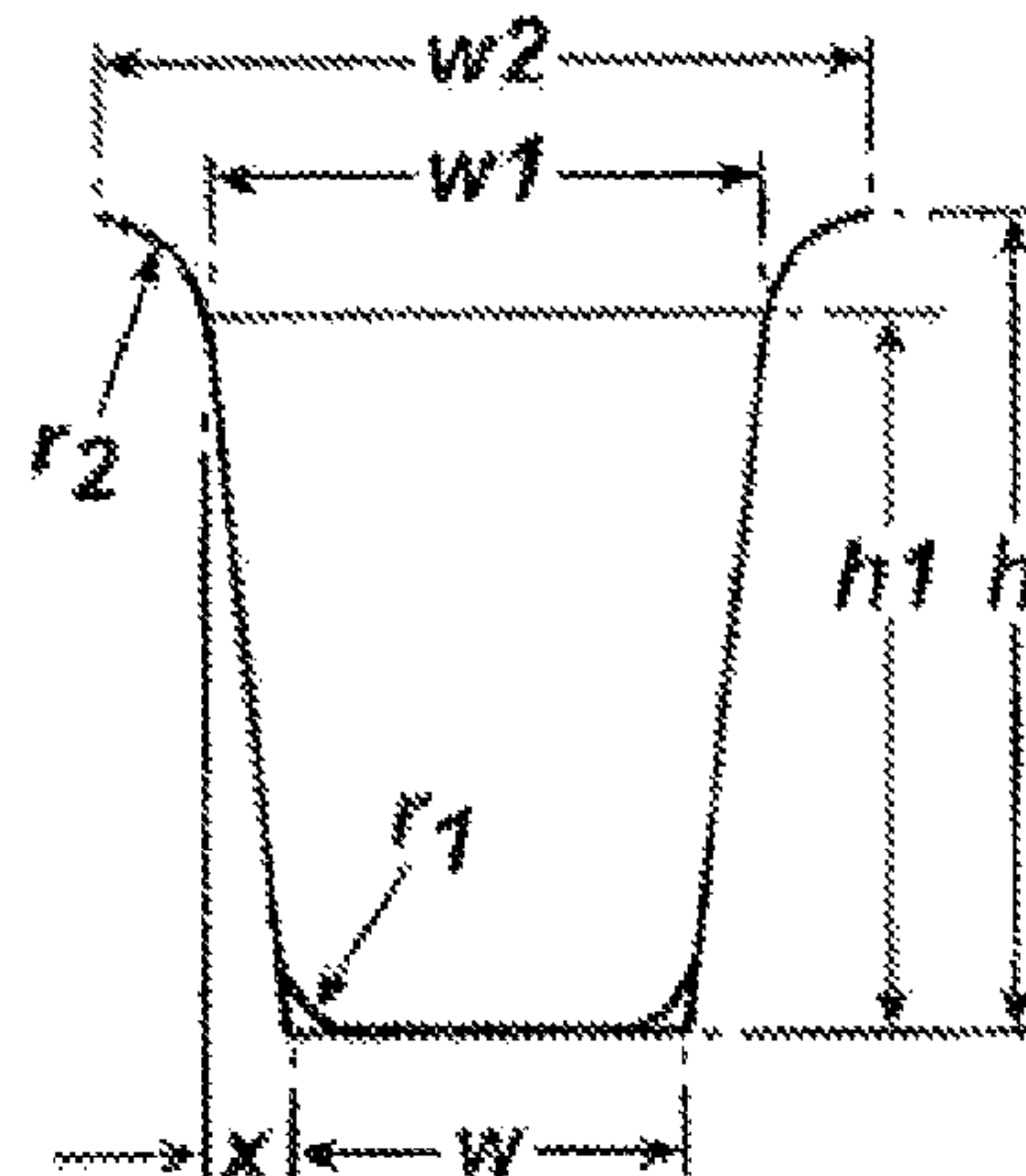
FIG. 30F



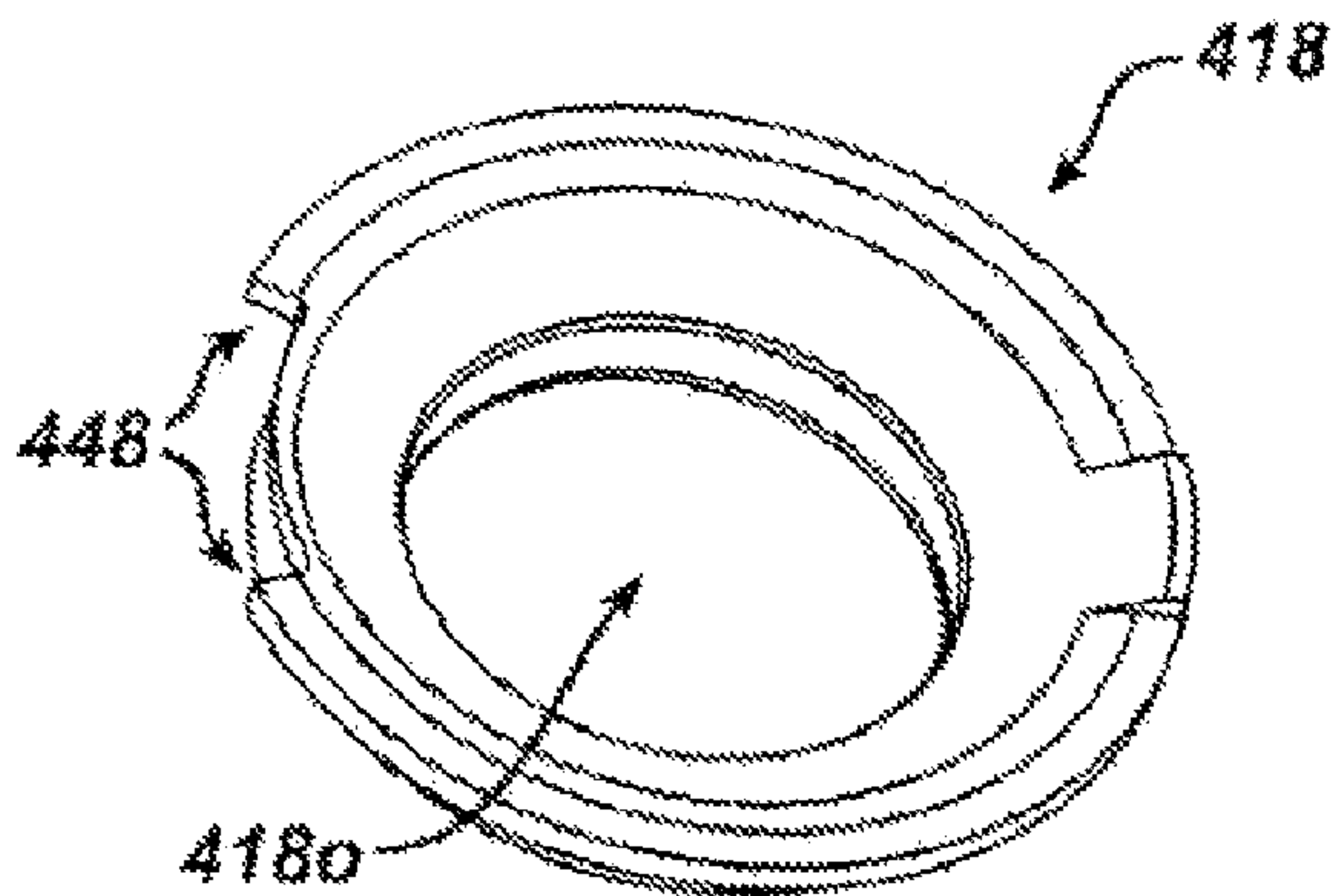
**FIG. 30G**



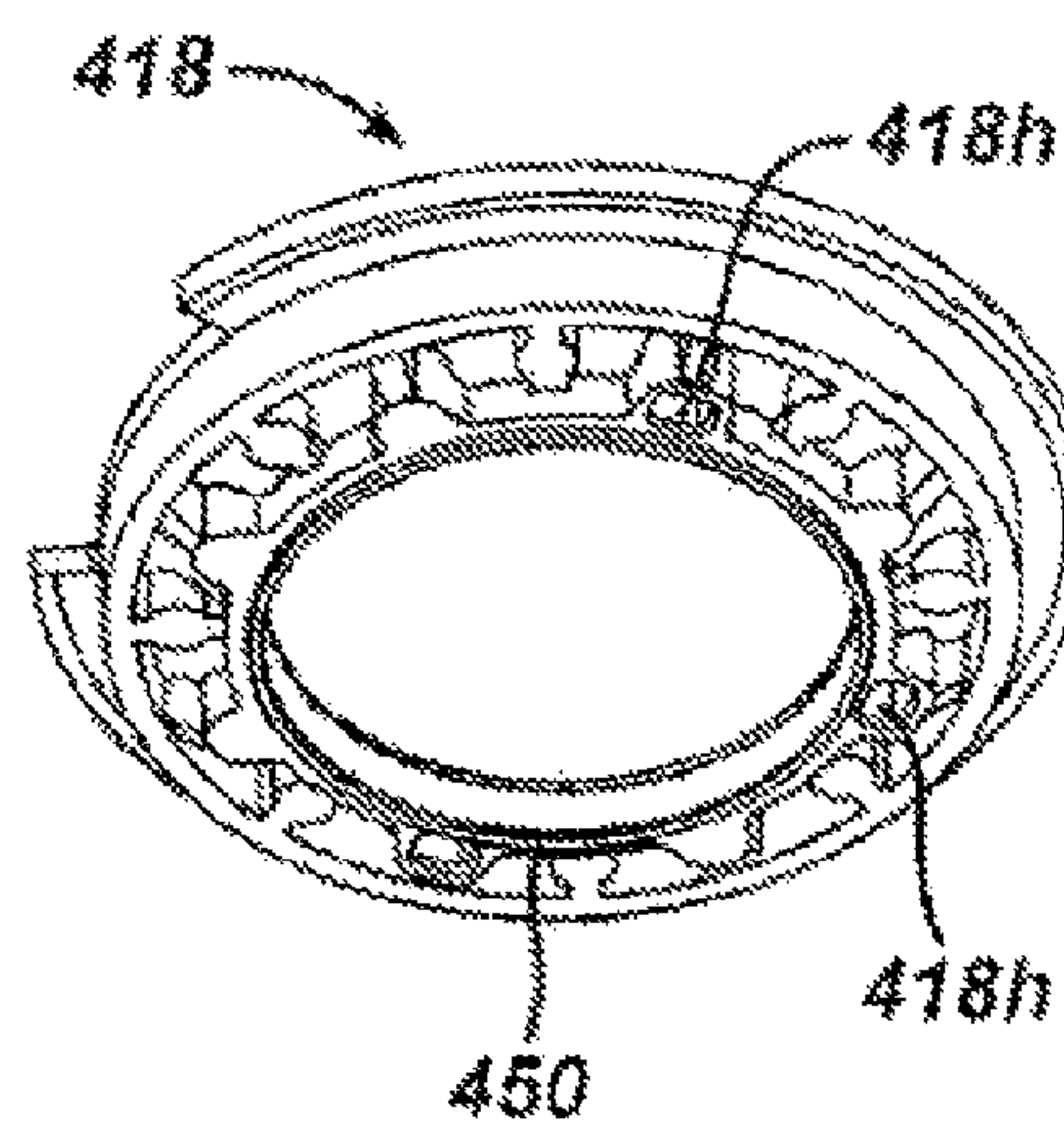
**FIG. 30H**



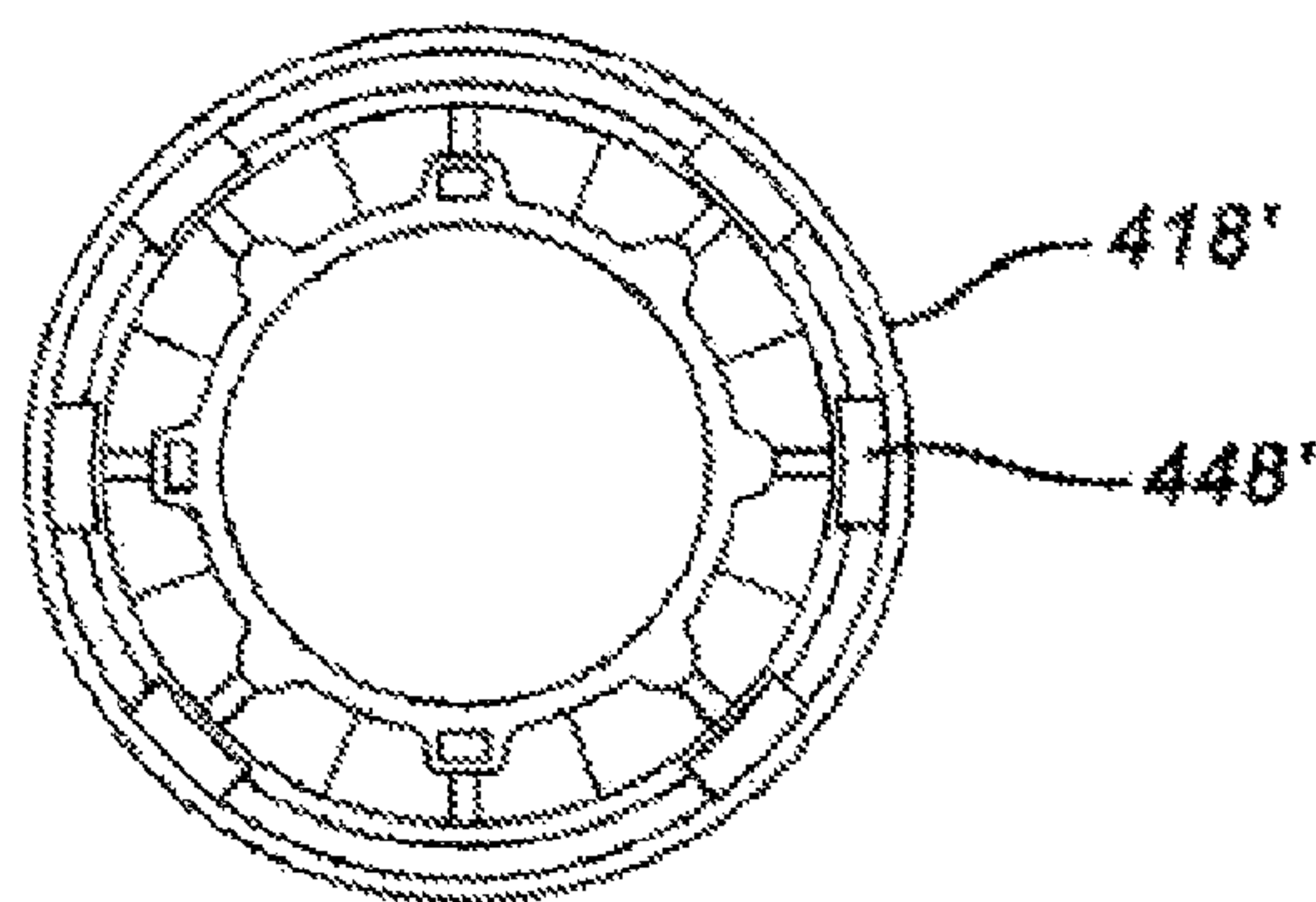
**FIG. 30I**



**FIG. 30J**



**FIG. 31**





**FIG. 32A**

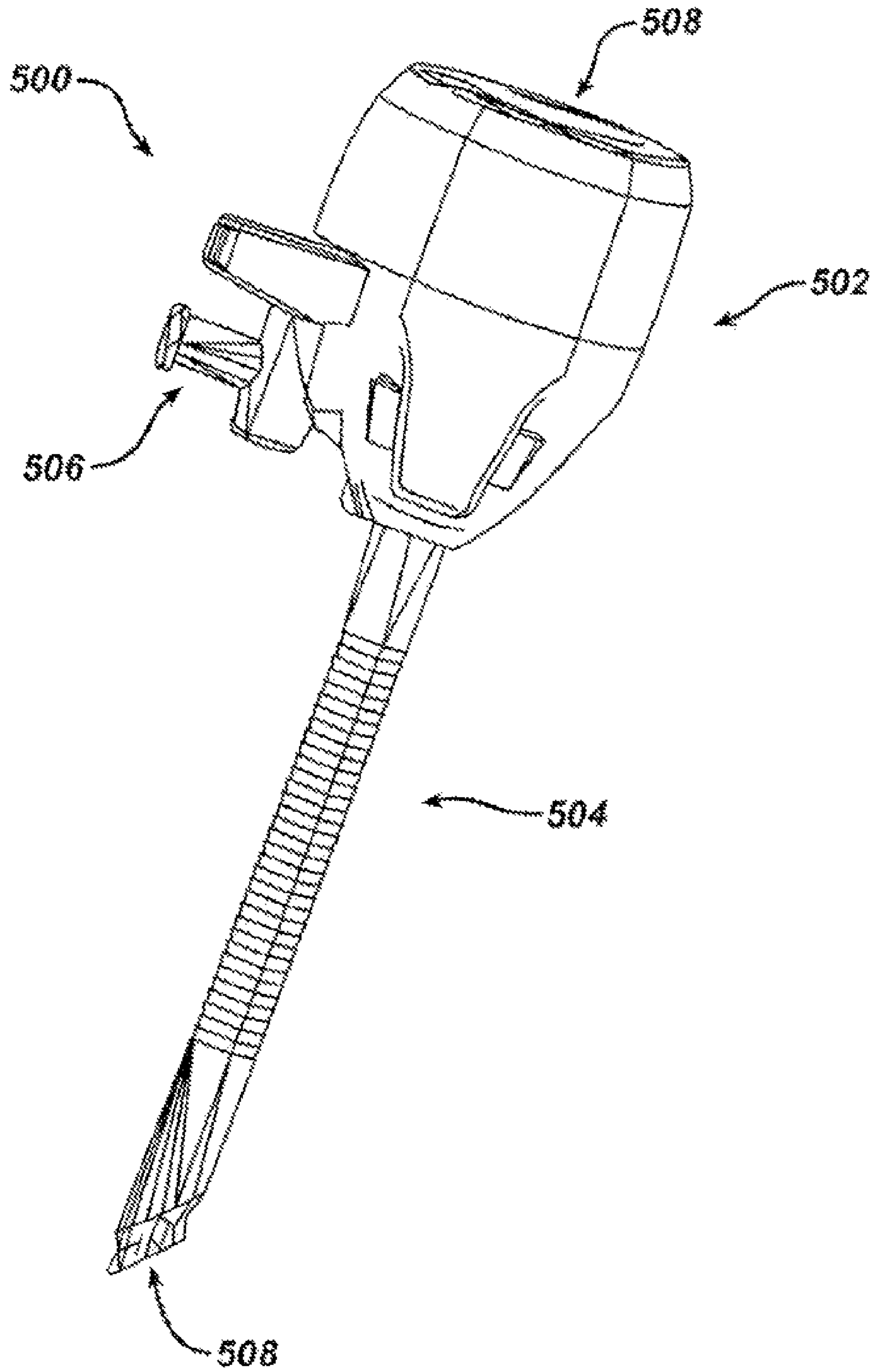


FIG. 32B

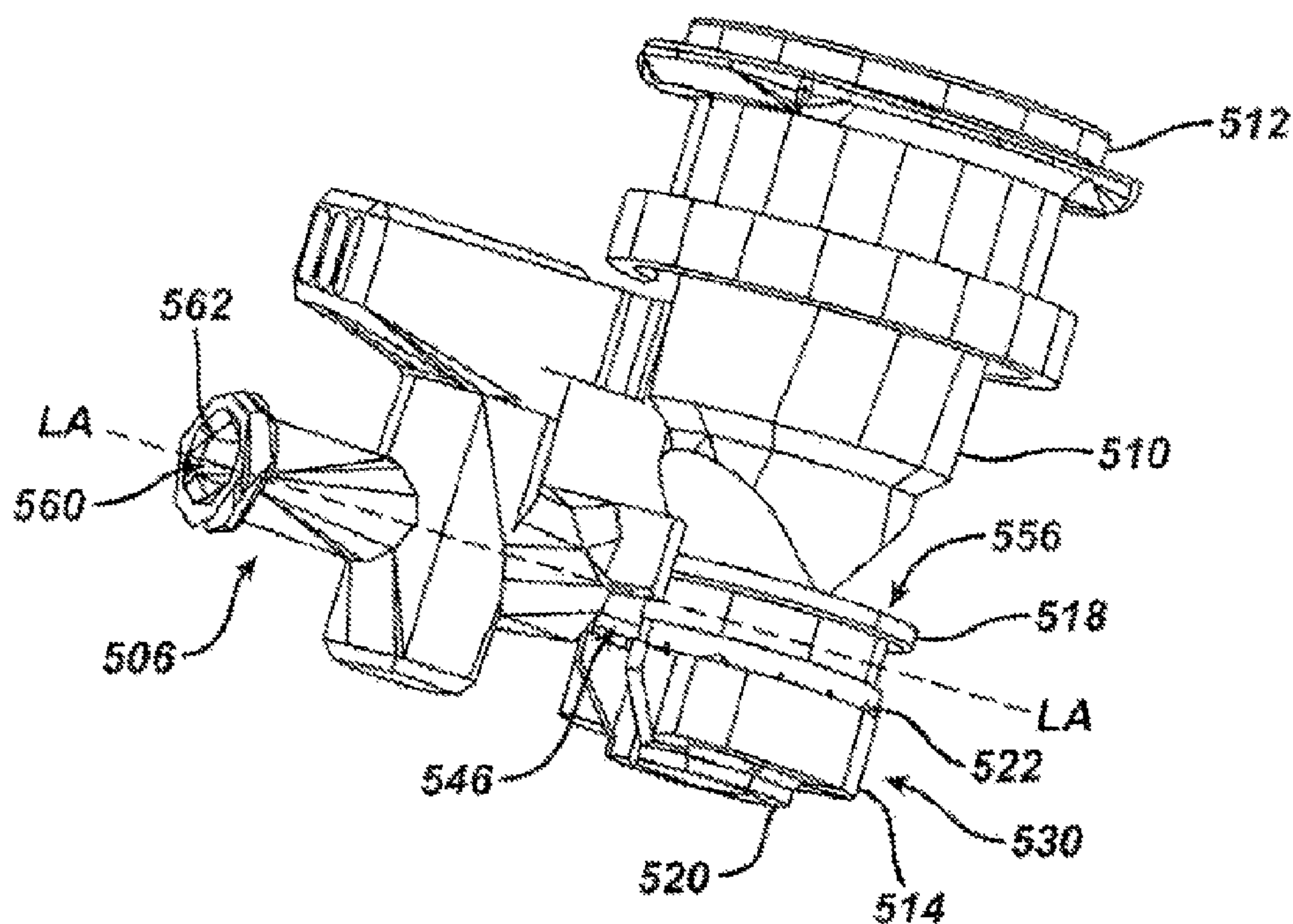
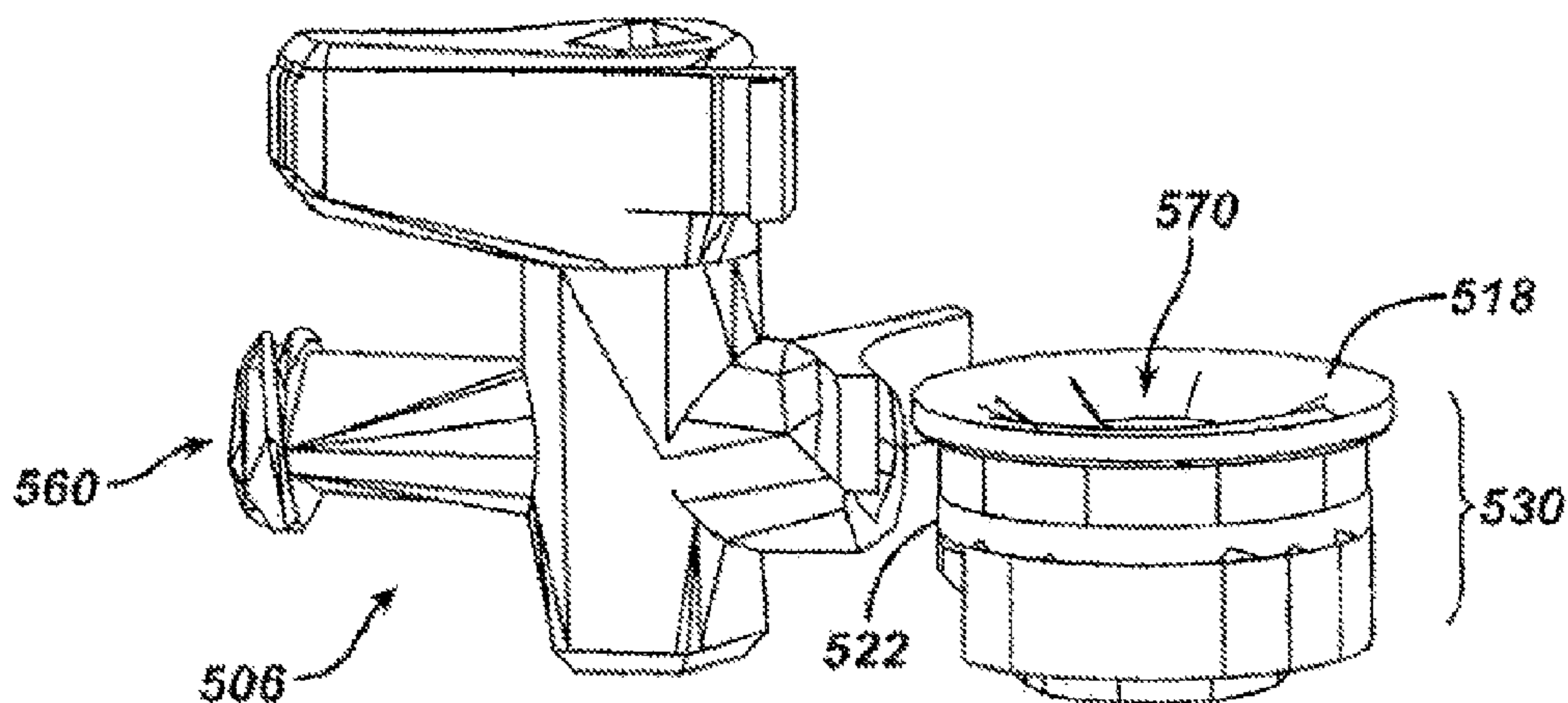
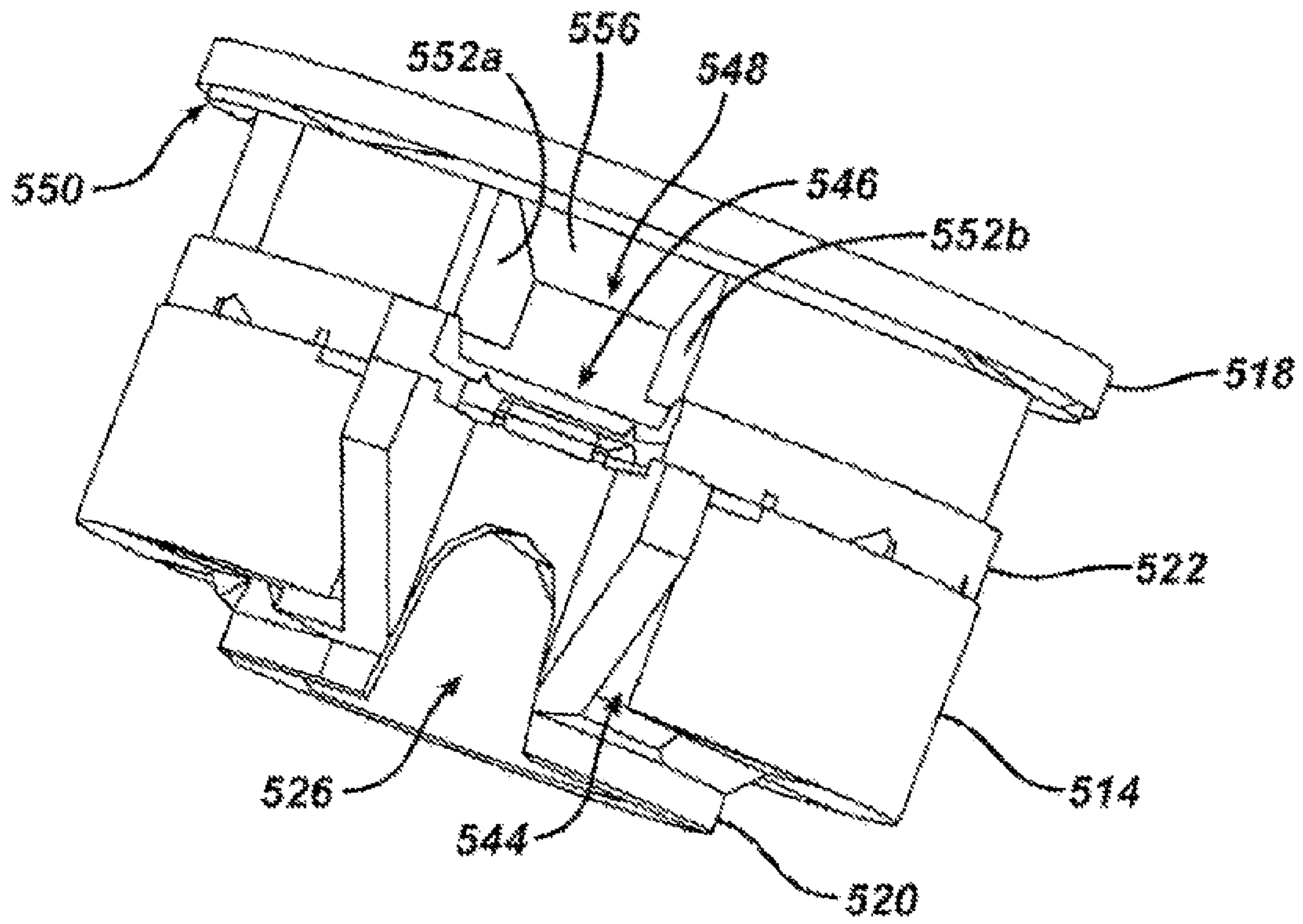


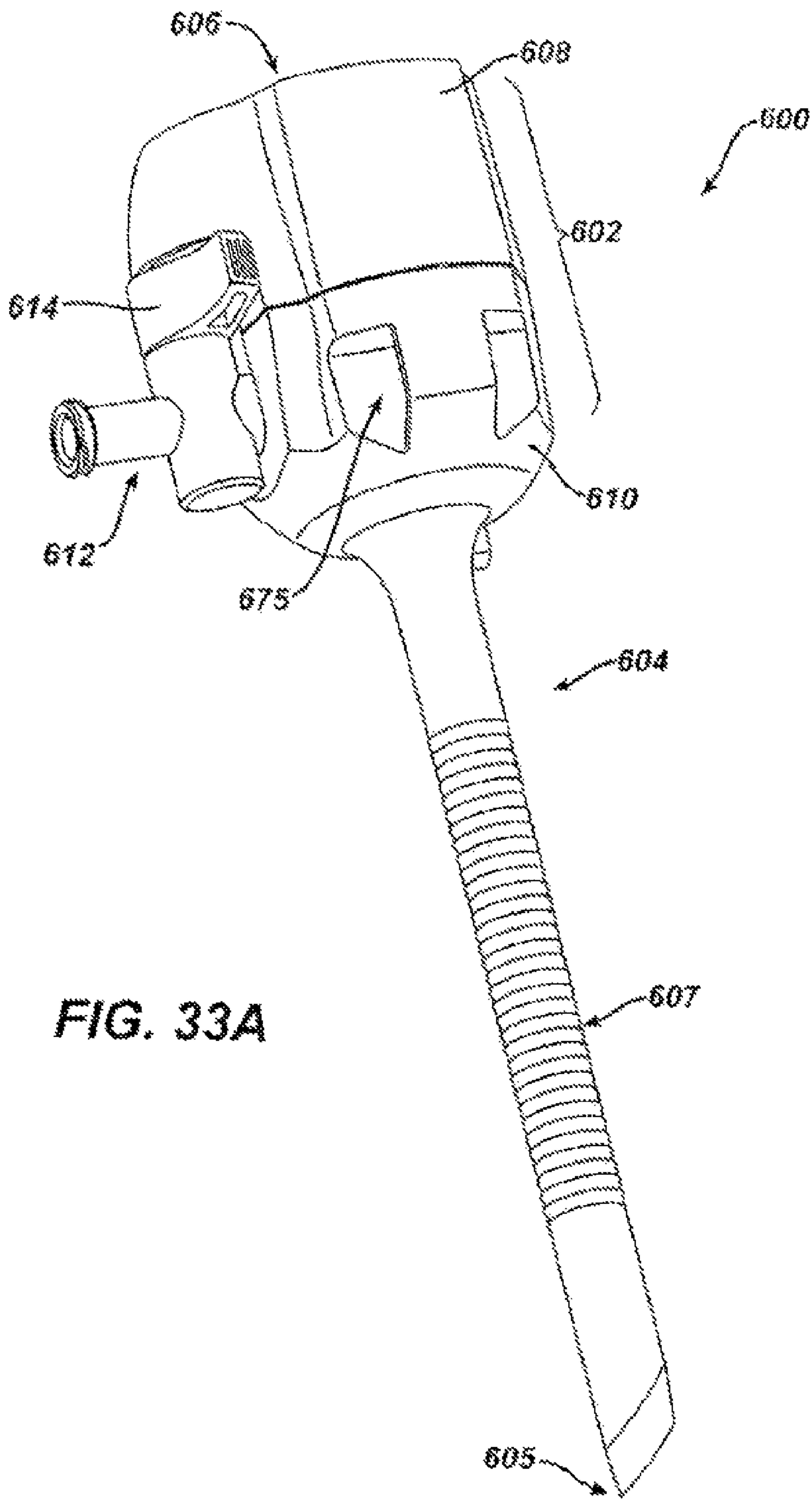
FIG. 32C

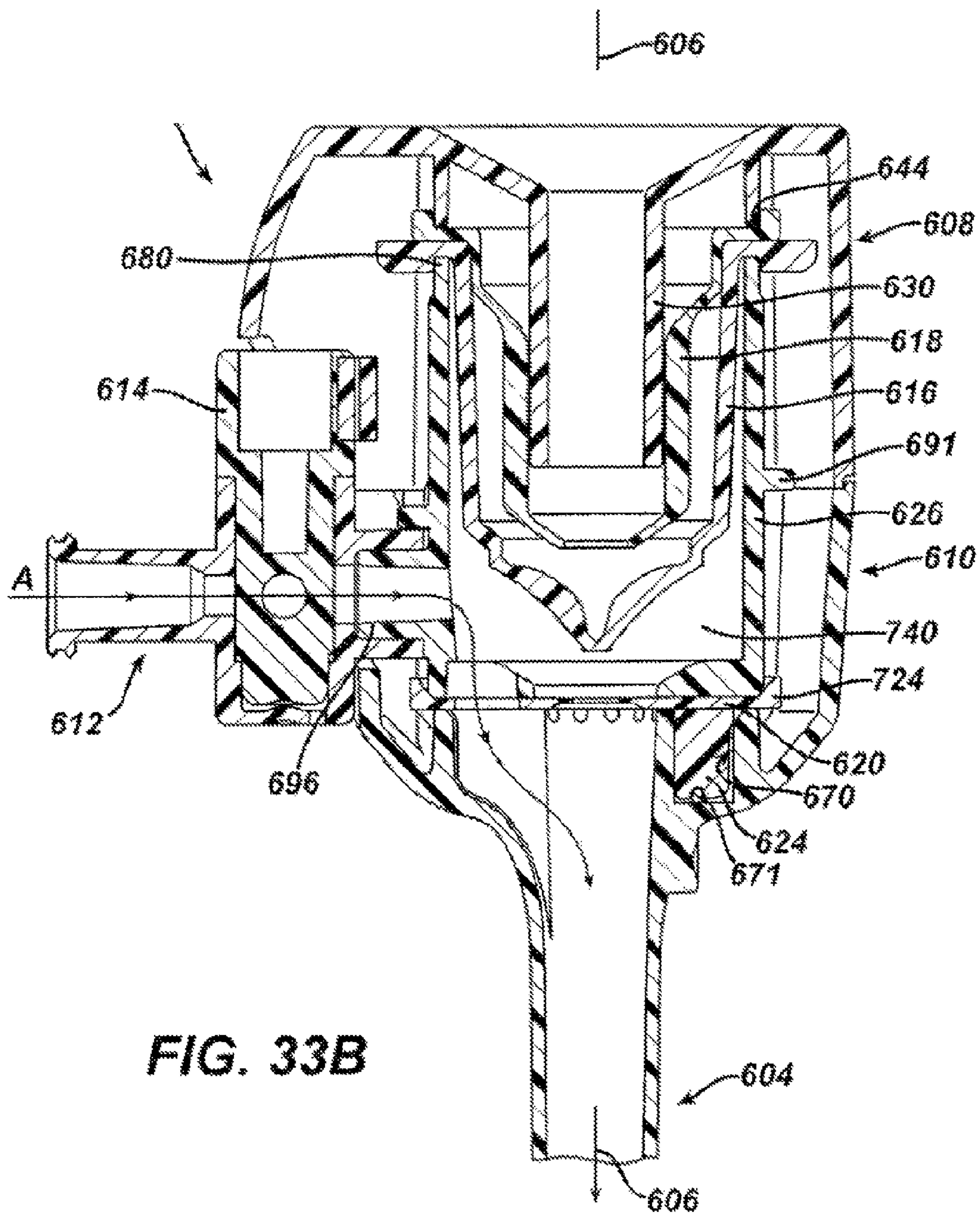


**FIG. 32D**

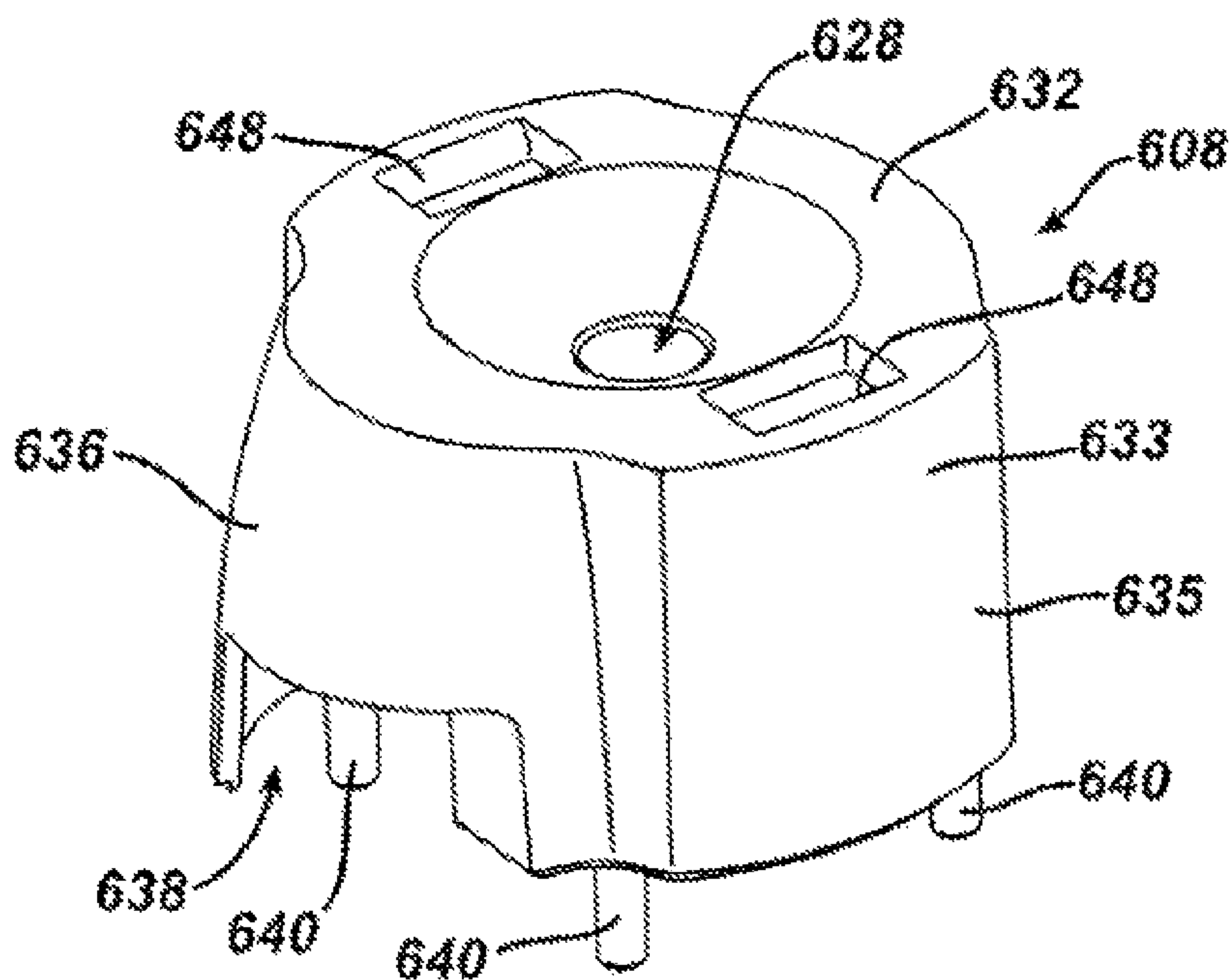




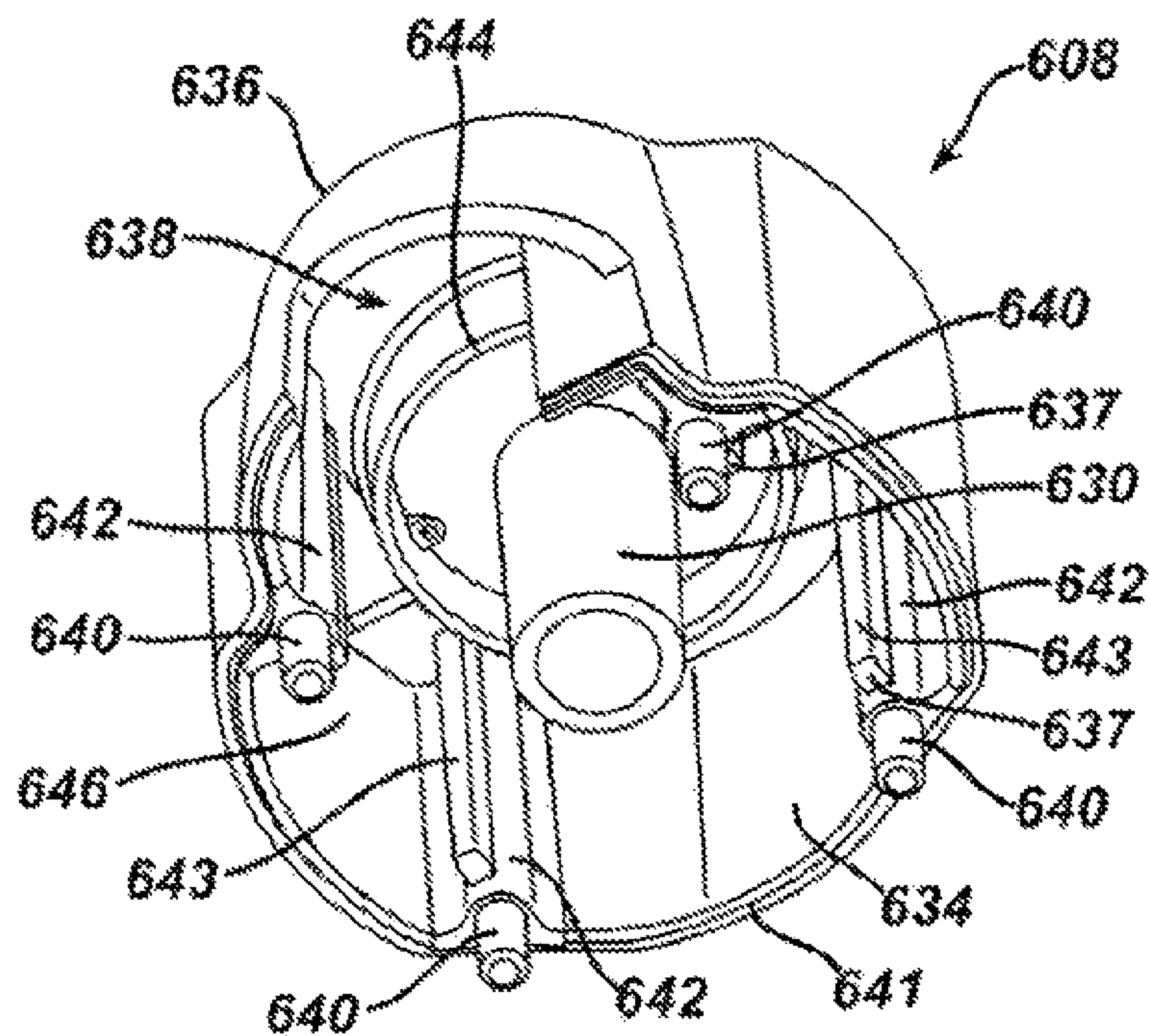




**FIG. 33B**



**FIG. 34A**



**FIG. 34B**



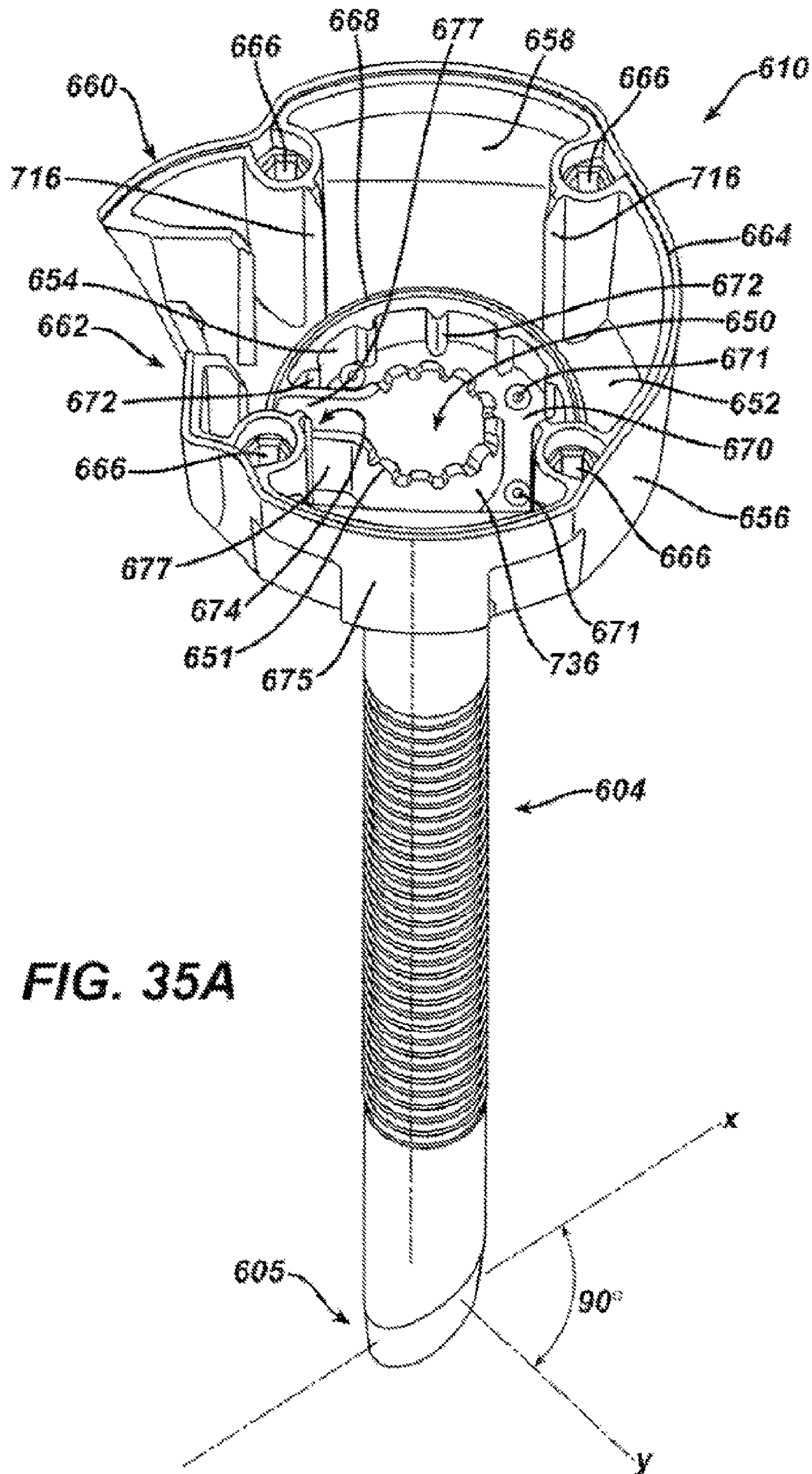
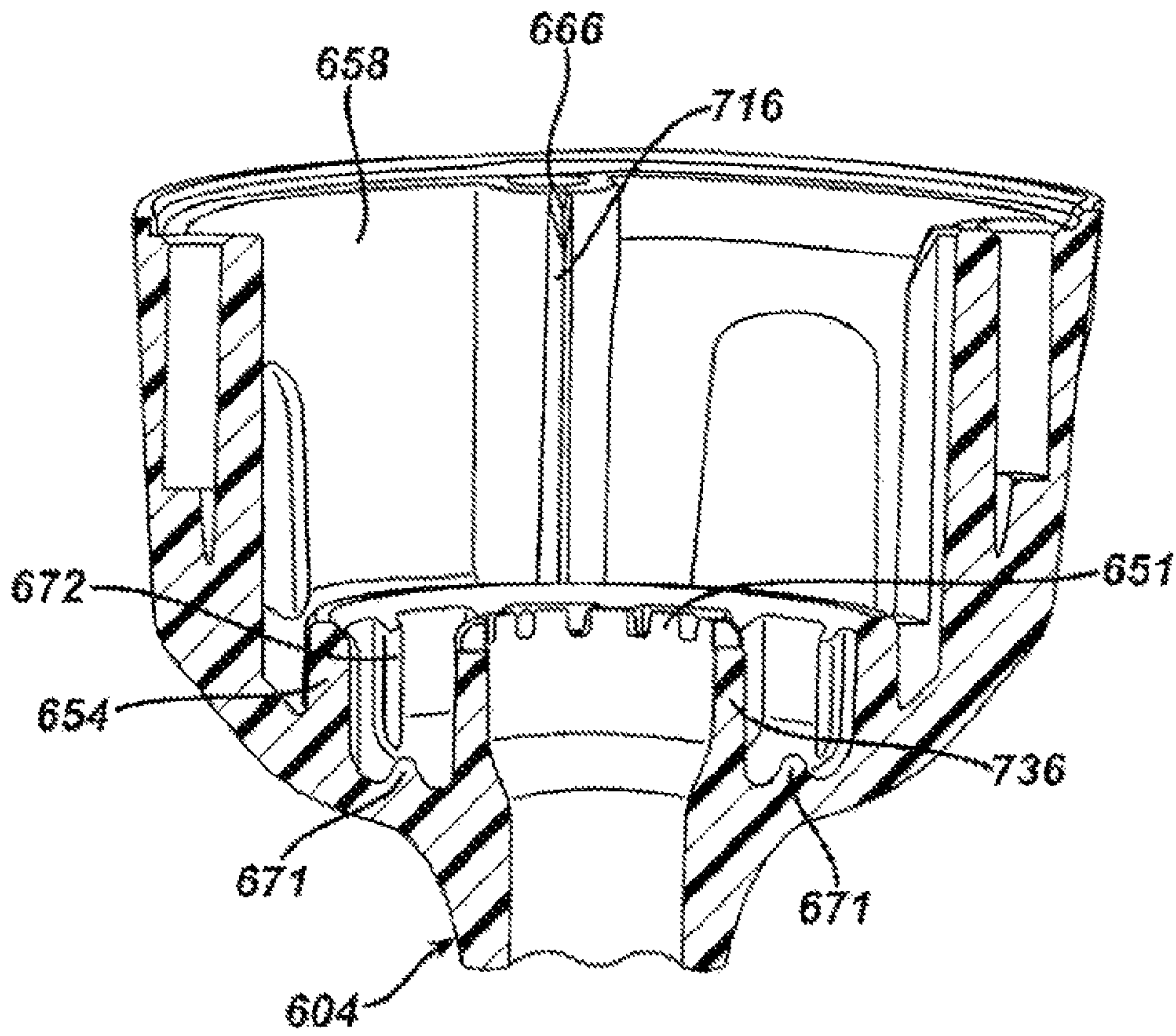
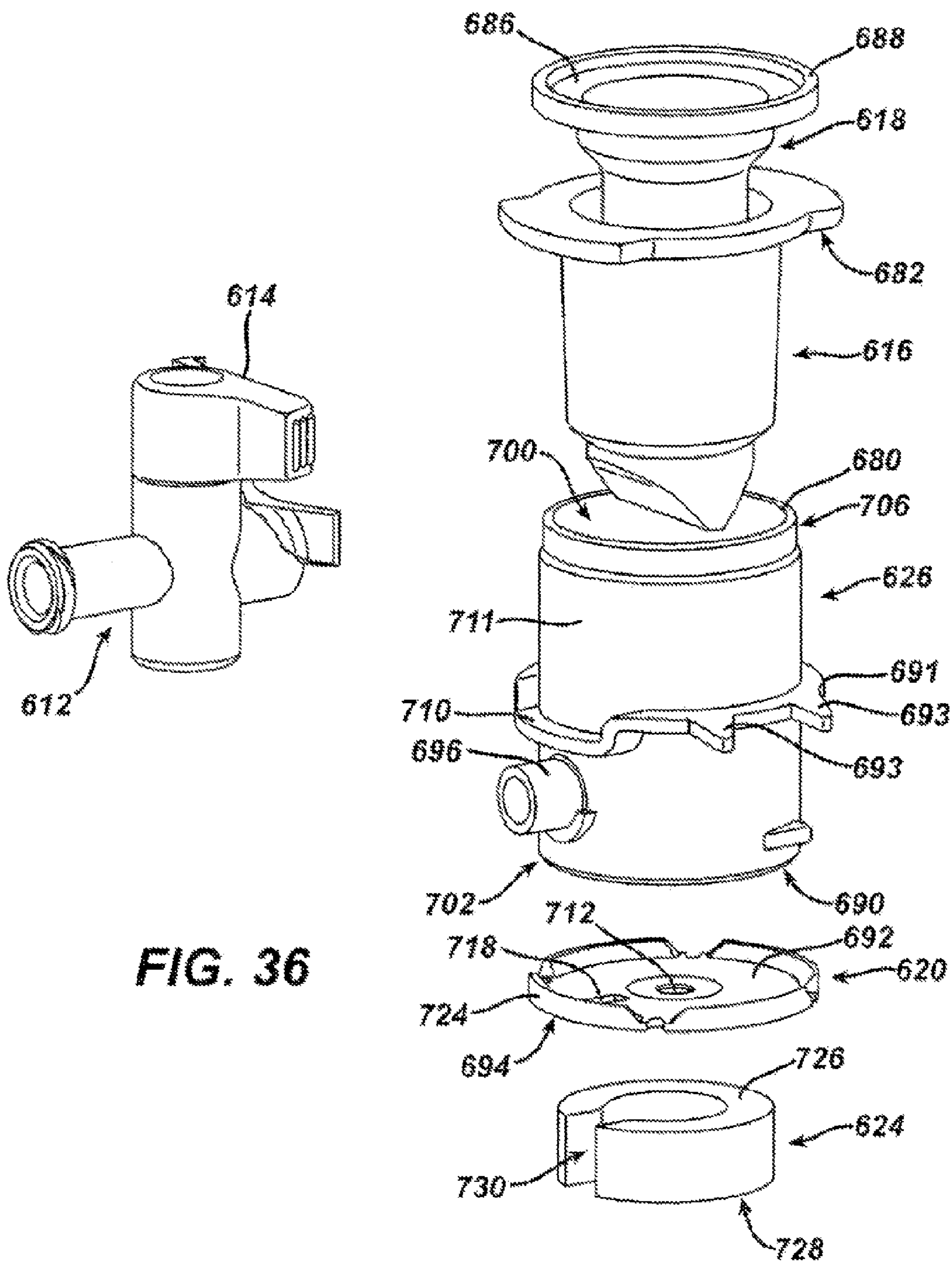


FIG. 35A



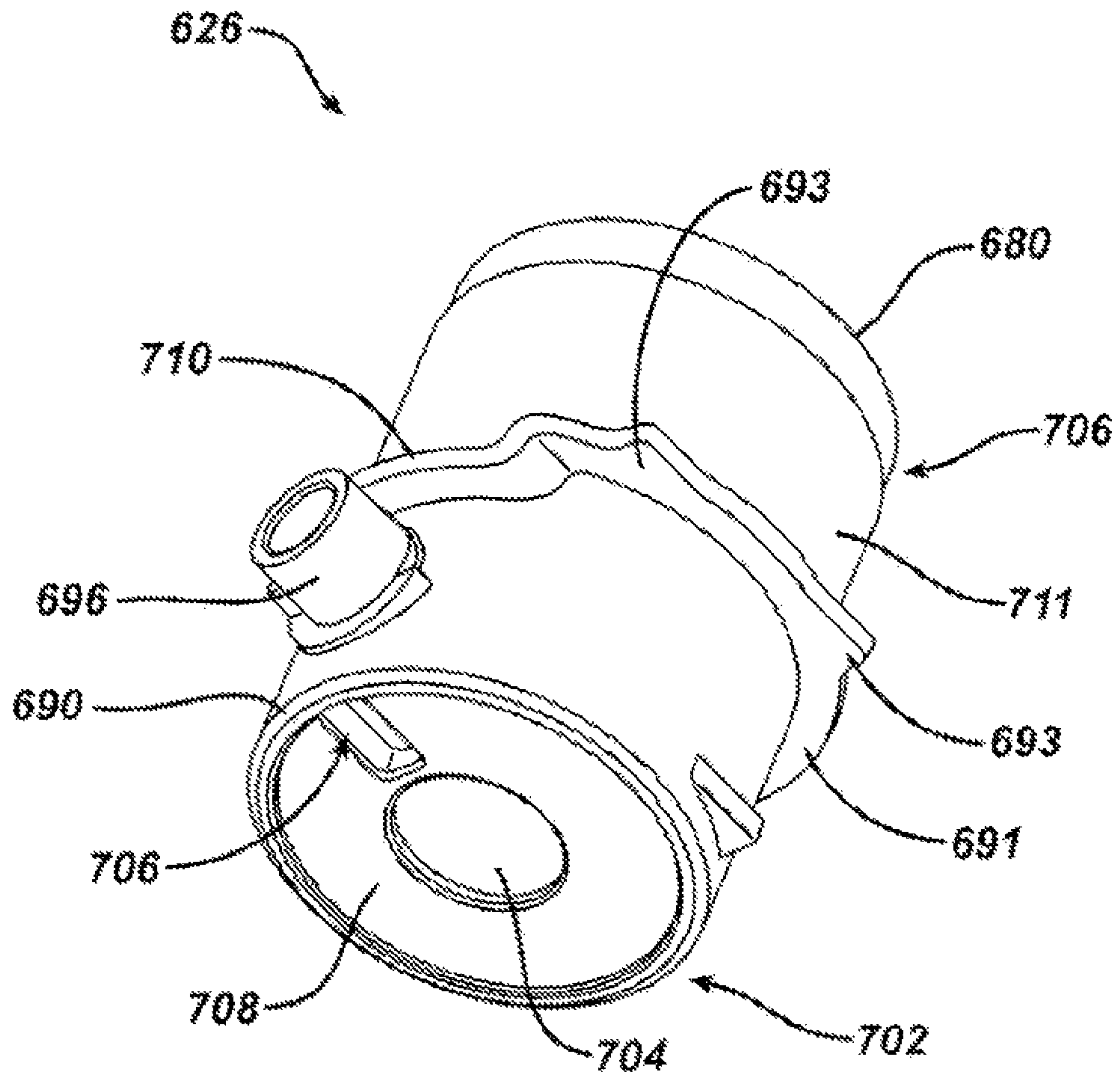


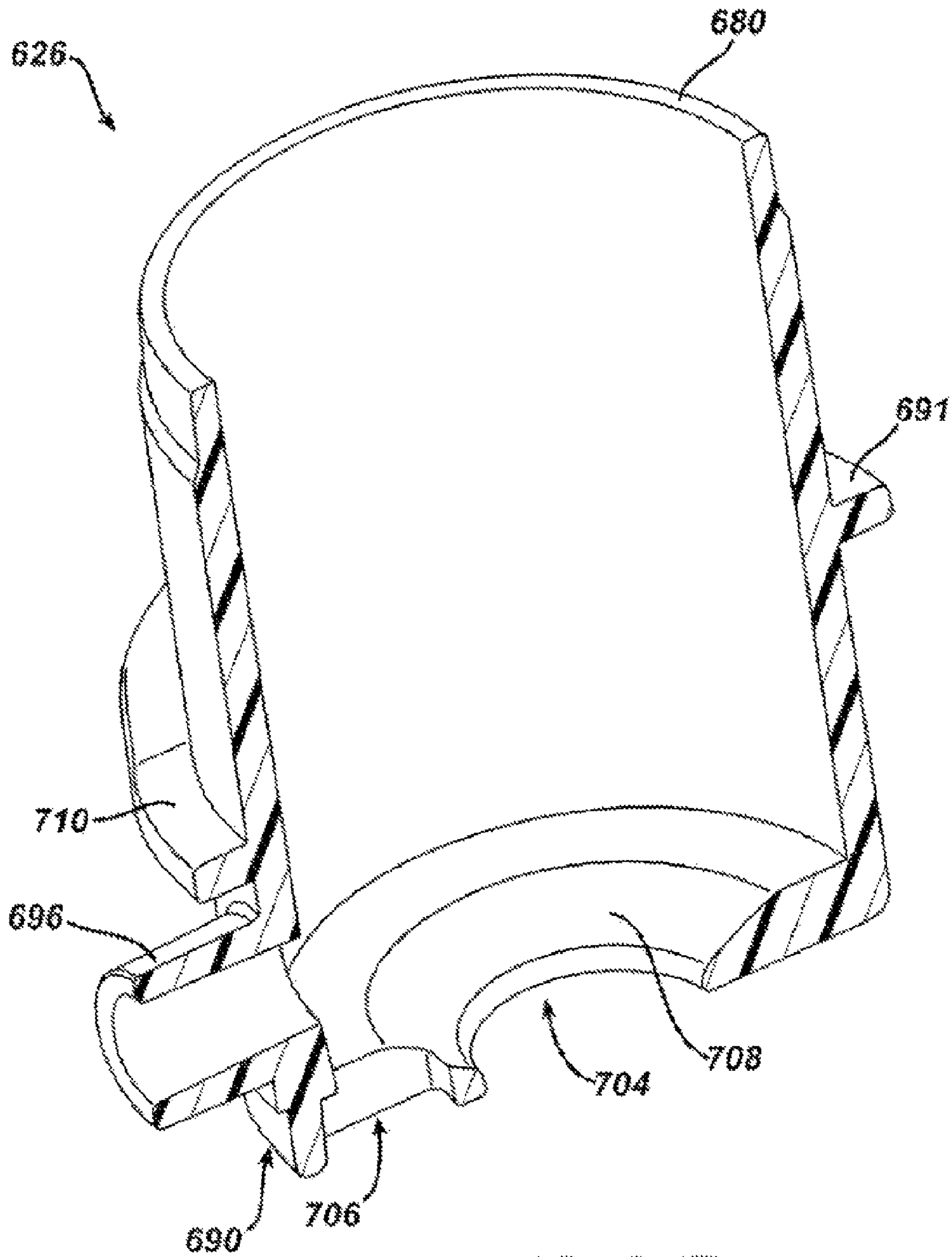
**FIG. 35B**



**FIG. 36**

**FIG. 37A**

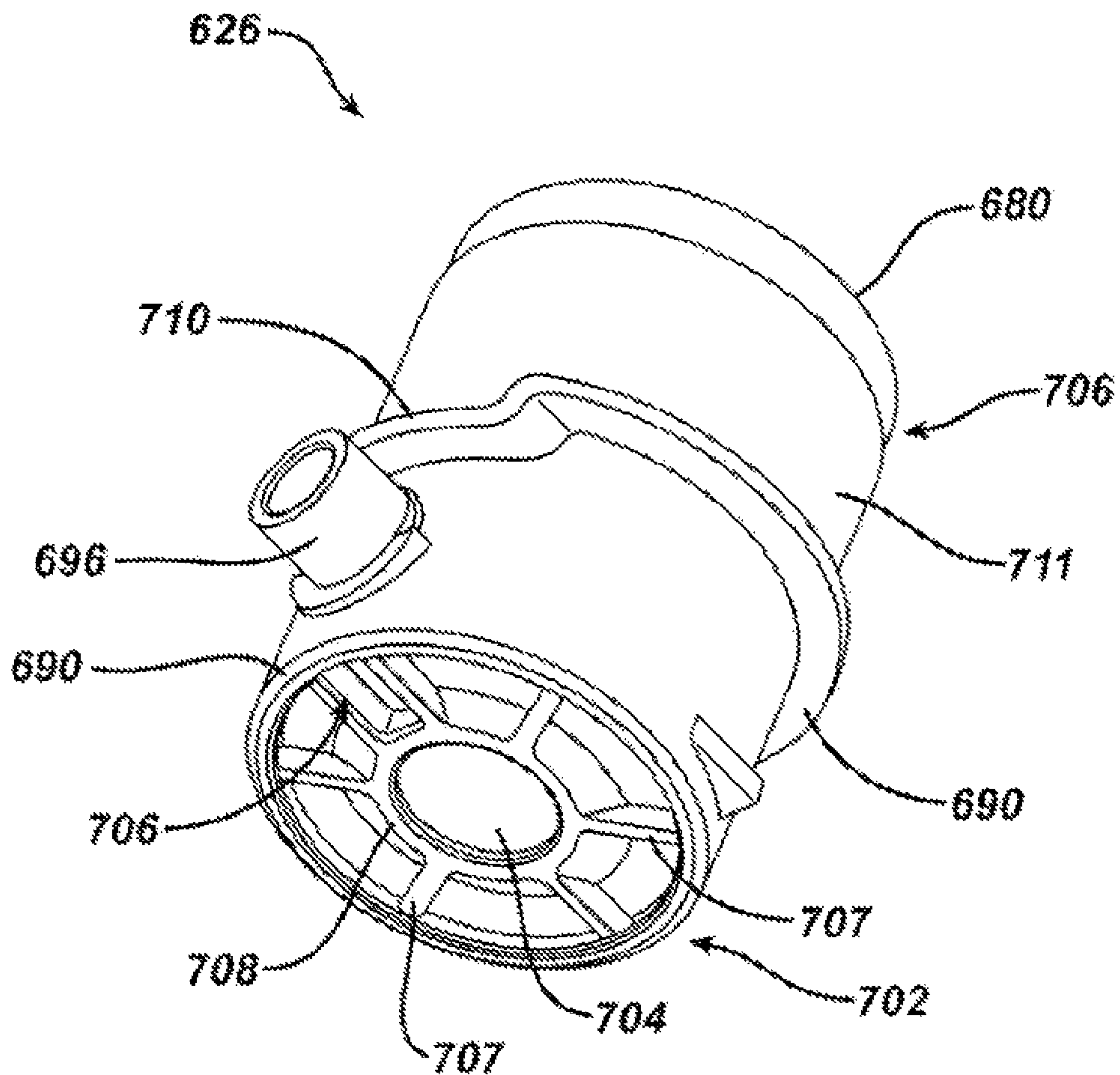


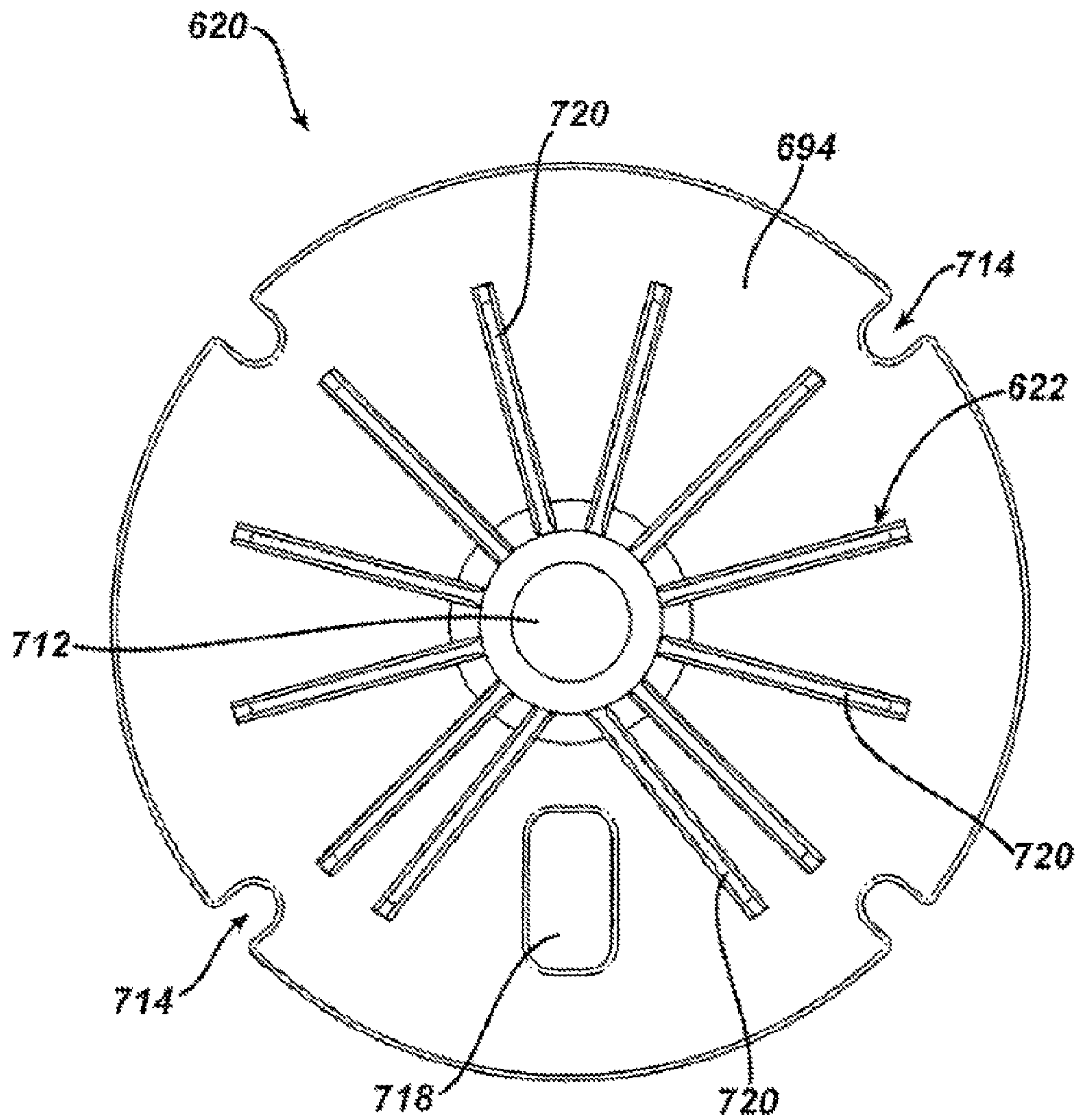


**FIG. 37B**

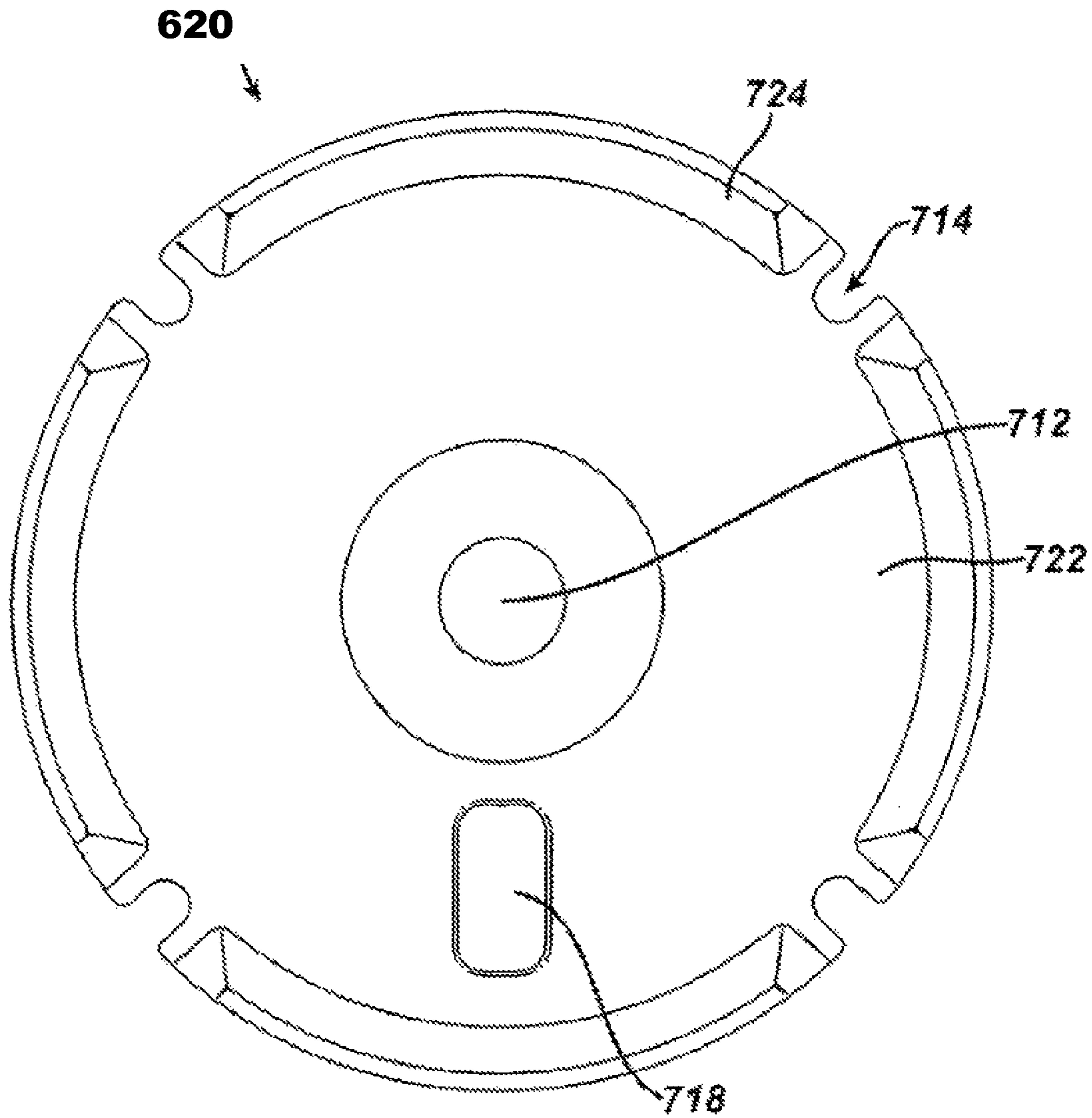


**FIG. 37C**

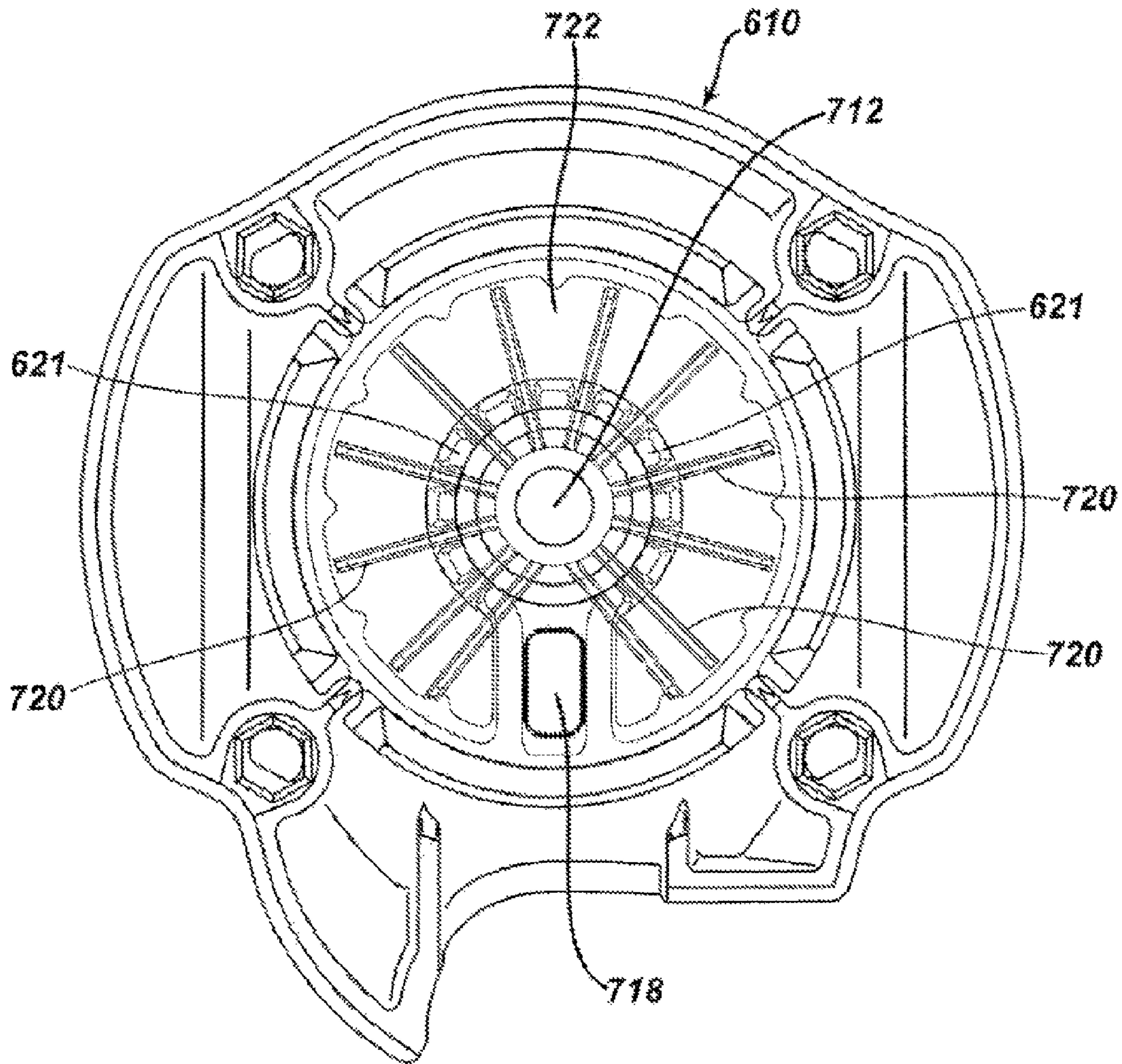




**FIG. 38A**

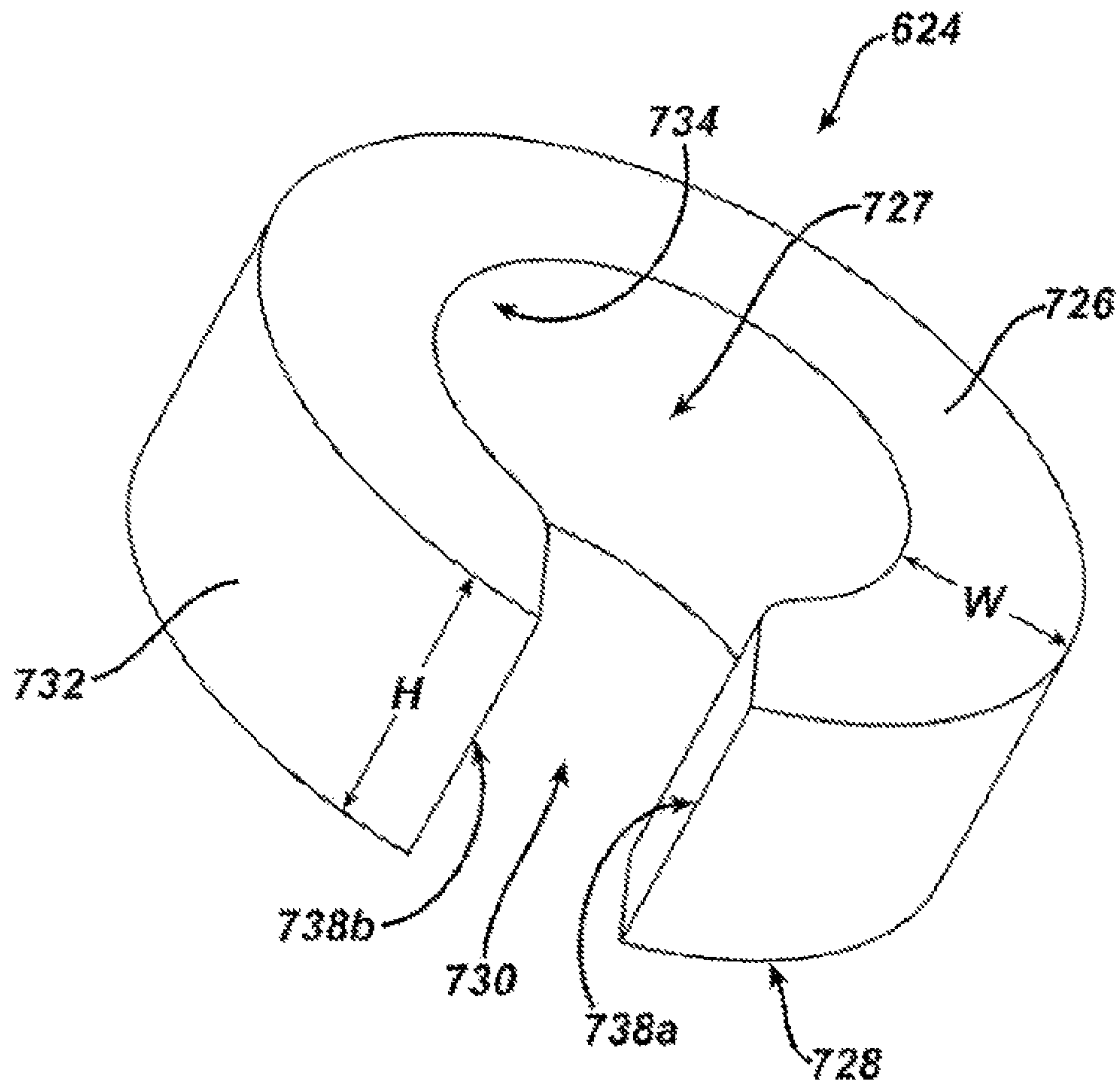


**FIG. 38B**



**FIG. 38C**





**FIG. 39**

**SURGICAL ACCESS DEVICE**  
CROSS-REFERENCE TO RELATED  
APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/902,265, filed on Oct. 12, 2010 and entitled "Surgical Access Device," which is a continuation-in-part of U.S. patent application Ser. No. 12/533,590 (now U.S. Pat. No. 8,568,362), filed on Jul. 31, 2009 and entitled "Surgical Access Devices with Sorbents," which is a continuation-in-part of: U.S. patent application Ser. No. 12/110,724 (Now U.S. Pat. No. 8,579,807), filed on Apr. 28, 2008 and entitled "Absorbing Fluids in a Surgical Access Device," U.S. patent application Ser. No. 12/110,727, filed on Apr. 28, 2008 and entitled "Scraping Fluid Removal in a Surgical Access Device," U.S. patent application Ser. No. 12/110,742, filed on Apr. 28, 2008 and entitled "Wicking Fluid Management in a Surgical Access Device," and U.S. patent application Ser. No. 12/110,755 (Now U.S. Pat. No. 8,273,060), filed on Apr. 28, 2008 and entitled "Fluid Removal in a Surgical Access Device," all of which are hereby incorporated by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates to methods and devices for performing surgical procedures, and in particular to methods and devices for maintaining visibility during surgical procedures.

BACKGROUND OF THE INVENTION

During laparoscopic surgery, one or more small incisions are formed in the abdomen and a trocar is inserted through the incision to form a pathway that provides access to the abdominal cavity. The trocar is used to introduce various instruments and tools into the abdominal cavity, as well as to provide insufflation to elevate the abdominal wall above the organs. During such procedures, a scoping device, such as an endoscope or laparoscope, is inserted through one of the trocars to allow a surgeon to view the operative field on an external monitor coupled to the scoping device.

Scoping devices are often inserted and removed through a trocar multiple times during a single surgical procedure, and during each insertion and each removal they can encounter fluid that can adhere to the scopes lens and fully or partially impede visibility through the lens. Furthermore, a scope can draw fluid from inside or outside a patients body into the trocar, where the fluid can be deposited within the trocar until the scope or other instrument is reinserted through the trocar. Upon reinsertion, fluid can adhere to the scopes lens. The scopes lens thus needs to be cleaned to restore visibility, often multiple times during a single surgical procedure. With limited access to a scope in a body, each lens cleaning can require removing the scope from the body, cleaning the scope lens of fluid, and reintroducing the scope into the body. Such lens cleaning is a time-consuming procedure that also increases the chances of complications and contamination through repeated scope insertion and removal.

Accordingly, there is a need for methods and devices for maintaining clear visibility through a lens of a scoping device during a surgical procedure.

SUMMARY OF THE INVENTION

The present invention generally provides methods and devices for preventing fluid deposit onto and/or for remov-

ing fluid from a surgical instrument. In one embodiment, a surgical access device is provided and can include a housing defining a working channel sized and configured to receive a surgical instrument. An insufflation port can be formed in the housing and it can be configured to deliver an insufflation gas to the working channel. Further, a seal can be disposed within the housing and it can be positioned proximal to the insufflation port. In some embodiments, the seal can be configured to receive a surgical instrument passed through the working channel.

A fluid remover can be disposed within the housing and it can be positioned distal to the insufflation port. The fluid remover can have many configurations, for example, the fluid remover can have an outer perimeter mounted within the housing and a central opening configured to receive surgical instruments therethrough. In some embodiments, the outer perimeter can be in sealing engagement with the housing. The fluid remover can be configured to allow insufflation gas to pass therethrough when an instrument occludes the central opening. The fluid remover can be, for example, a scraper configured to scrape fluid away from surgical instruments inserted through the central opening.

In some embodiments, the scraper can include a wicking element formed thereon and configured to wick fluid away from the central opening in the scraper. The wicking element can have many different configurations, for example, the wicking element can be in the form of a plurality of channels formed in a distal surface of the scraper and extending radially outward from the central opening such that fluid scraped off of a surgical instrument can flow into the channels. The fluid remover can also include a sorbent disposed distal to the scraper and configured to receive fluid scraped by the scraper. In one embodiment, the fluid remover can include a hole formed therein and positioned a distance away from the central opening and the outer perimeter. The hole can be configured to allow insufflation gas to pass therethrough.

As will be appreciated by those having ordinary skill in the art, the housing can have many configurations. In one embodiment, the housing can include a proximal housing portion and a distal housing portion having a cannula extending distally therefrom. The proximal and distal housing portions can be disposed around an inner retainer, and the working channel can extend through the inner retainer and the cannula. The outer perimeter of the fluid remover can be in sealing engagement with the inner retainer and the distal housing portion. In some embodiments, the seal can be captured between the inner retainer and the proximal housing portion.

The distal cannula can include an angled distal surface having a distal-most point and a proximal-most point. In some embodiments, the distal-most point can be aligned with the insufflation port, although it can have any angular orientation as desired. The surgical access device can also include at least one opening formed on an outside wall of the housing that can be configured for receiving suture.

In other aspects, a surgical access device is provided and can include a housing and a cannula extending distally from the housing. The housing and the cannula can have a working channel extending therethrough between a proximal opening formed in a proximal end of the housing and a distal end of the cannula. The working channel can be sized and configured to receive a surgical instrument. An insufflation port can be coupled to the housing and configured to receive and deliver an insufflation gas to the working channel. Further, a seal can be disposed within the housing and configured to substantially prevent passage of an insufflation



gas from the insufflation port to the proximal opening when no surgical instrument is disposed therethrough.

In some embodiments, a fluid remover can be disposed within the housing and can be positioned distal of the seal. The fluid remover can have an outer perimeter in sealing engagement with the housing. The fluid remover can also have a central opening formed therethrough positioned to receive a surgical instrument passed through the working channel. Further, the fluid remover can include a hole formed therein between the central opening and the outer perimeter that is configured to allow insufflation gas to pass from the insufflation port to the cannula when an instrument is disposed through and occludes the central opening in the fluid remover.

While the fluid remover can have many configurations, in one embodiment, the fluid remover can be a scraper configured to scrape fluid off of a surgical instrument passed through the opening. The surgical access device can also include a sorbent disposed within the housing at a location distal to the scraper. The sorbent can be configured to sorb fluid removed by the scraper. In some embodiments, the surgical access device can further include a wicking element formed on the scraper and configured to wick fluid away from the central opening in the scraper. The sorbent can have, for example, a central opening formed therethrough and can be axially aligned with the central opening in the scraper. In one embodiment, the central opening in the sorbent can have a diameter greater than a diameter of the central opening in the scraper. The insufflation port can be positioned anywhere within the housing, for example, the insufflation port can be positioned proximal to the fluid remover.

While the housing can have many configurations, in one embodiment, the housing can include a proximal housing portion and a distal housing portion disposed around an inner retainer. The working channel can extend through the inner retainer, and the outer perimeter of the fluid remover can be in sealing engagement with the inner retainer. The proximal opening can be formed in the proximal housing. In some embodiments, the inner retainer can be captured between the proximal and distal housing portions.

In further aspects, methods are also provided. For example, a method for removing fluid from a surgical access device is provided and can include inserting a surgical access device through tissue such that the surgical access device provides a working channel extending through the tissue and into a body cavity. Further, a surgical instrument can be inserted through the working channel of the surgical access device such that a central opening formed in a scraper disposed within the working channel engages a circumference of the surgical instrument. The method can further include delivering an insufflation gas through an insufflation port in the surgical access device to insufflate the body cavity. The insufflation gas can pass through a hole formed in the scraper.

In some embodiments, inserting a surgical instrument through the working channel of a surgical access device can include inserting a surgical instrument through a seal in a working channel of a surgical access device extending into a body cavity. The seal can move from a closed position in which the working channel is sealed to an open position as the surgical instrument is passed therethrough. Further, a fluid remover disposed distal of the seal can scrape fluid from the surgical instrument and invert proximally to transfer the fluid away from the surgical instrument. Fluid scraped by the scraper can be transferred to a sorbent.

In other aspects, a method for reprocessing a surgical access device is provided and includes removing a scraper from a surgical access device, cleaning the scraper, treating a surface of the scraper with a surfactant, and replacing the scraper in the surgical access device. In some embodiments, the surfactant can be dodecylbenzene sodium sulfonate or sodium dodecyl sulfate. In other embodiments, the scraper can be formed from a hydrophobic material such as a polyisoprene.

In still further aspects, a method for reprocessing a surgical access device is provided and includes removing a first sorbent from a surgical access device, treating a second sorbent with a surfactant, and replacing the first sorbent with the second sorbent in the surgical access device. In some embodiments, the surfactant can be dodecylbenzene sodium sulfonate or sodium dodecyl sulfate.

In another aspect, a fluid remover for use in a surgical access device is provided and can include a housing defining a working channel sized to receive a surgical instrument, an insufflation port disposed in the housing, and a seal disposed proximal to the insufflation port. In some embodiments, the fluid remover can include a fluid removing member having an outer perimeter and a central opening formed therein for receiving and sealing around a surgical access device. The fluid removing member can also have a hole disposed radially outward from the central opening and radially inward from the outer perimeter and can be configured to allow insufflation gas to pass therethrough.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1A is a perspective view of one embodiment of a trocar;

FIG. 1B is an exploded view of the trocar of FIG. 1A;

FIG. 1C is a cross-sectional view of a portion of the trocar of FIG. 1A;

FIG. 1D is a bottom perspective view of an instrument seal assembly for use with the trocar of FIG. 1A;

FIG. 1E is an exploded view of the instrument seal assembly of FIG. 1D;

FIG. 1F is a perspective view of a channel seal of the trocar of FIG. 1A;

FIG. 1G is a bottom perspective view of one embodiment of a scraper of a fluid remover assembly for use with the trocar of FIG. 1A;

FIG. 1H is a perspective view of one embodiment of a sorbent wick of a fluid remover assembly for use with the trocar of FIG. 1A;

FIG. 1I is a perspective view of a sorbent element of a fluid remover assembly for use with the trocar of FIG. 1A;

FIG. 1J is a perspective view of a frame for housing the sorbent element of FIG. 1I;

FIG. 1K is a perspective view of a lid portion of a fluid remover assembly for use with the trocar of FIG. 1A;

FIG. 2A is a cross-sectional view of a proximal portion of another embodiment of a trocar;

FIG. 2B is an exploded view of the trocar of FIG. 2A;

FIG. 3A is an exploded view of a portion of a trocar having a drop-in fluid remover assembly;

FIG. 3B is an exploded view of the drop-in fluid remover assembly of FIG. 3A;

FIG. 3C is a cross-sectional view of a trocar of FIG. 3A;

FIG. 4A is an exploded view of one embodiment of a scraper assembly for scraping fluid;



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FIG. 4B is a bottom perspective view the scraper assembly of FIG. 4A;

FIG. 4C is a top perspective view of the scraper assembly of FIG. 4A;

FIG. 5A is a perspective view of another embodiment of fluid remover assembly having a scraper nested within a sorbent element;

FIG. 5B is top view of the fluid remover assembly of FIG. 5A;

FIG. 5C is a cross-sectional view of the fluid remover assembly of FIG. 5A disposed within a trocar housing;

FIG. 6A is a cross-sectional view of a trocar having one embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 6B is a cross-sectional view of a trocar having another embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 6C is a cross-sectional view of a trocar having yet another embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 7 is a cross-sectional view of another embodiment of a trocar housing having sorbent flapper doors positioned adjacent to a zero-closure seal;

FIG. 8 is a cross-sectional view of yet another embodiment of a trocar housing having wicking fingers coupled to a sorbent reservoir;

FIG. 9 is a cross-sectional view of one embodiment of a trocar housing having a sorbent element disposed therein;

FIG. 10A is a cross-sectional view of one embodiment of a zero-closure seal having extension members for wicking fluid;

FIG. 10B is a transparent perspective view of the seal of FIG. 10A;

FIG. 11 is an exploded view of another embodiment of fluid remover assembly having a sorbent element nested between first and second zero-closure seals;

FIG. 12A is a cross-sectional view of yet another embodiment of a sorbent element having two sorbent bars disposed within a zero-closure seal;

FIG. 12B is a transparent perspective view of the sorbent element and seal of FIG. 12A;

FIG. 13 is an exploded view of one embodiment of a trocar housing having a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 14 is a cross-sectional view of one embodiment of a trocar cap having a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 15A is a top view of a trocar cap having another embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 15B is a side perspective view of the trocar cap of FIG. 15A;

FIG. 16 is an exploded view of one embodiment of a multi-layer seal having a sorbent element disposed between the layers;

FIG. 17 is a bottom perspective view of one embodiment of a trocar cap having a sorbent element disposed therein;

FIG. 18A is a bottom perspective view of one embodiment of a wicking element formed on a portion of a seal protector for creating between the seal protector and a seal;

FIG. 18B is a top perspective view of the portion of the seal protector of FIG. 18A;

FIG. 19A is a top view of a multi-layer protective member having camming ribs;

FIG. 19B is a top view of one layer of the protective member of FIG. 19A;

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FIG. 20A is a side perspective view of a deep cone instrument seal having wicking ribs formed on an external surface;

FIG. 20B is a top perspective view of another embodiment of a deep cone instrument seal having wicking ribs formed on an internal surface;

FIG. 21 is a perspective view of a multi-layer protective element having holes formed therein for receiving fluid;

FIG. 22A is an exploded view of a multi-layer protective element;

FIG. 22B is a cross-sectional view taken across line B-B of one of the protective elements of FIG. 22A;

FIG. 23A is a side view of one embodiment of a seal having an hourglass configuration for scraping fluid off of a surgical instrument;

FIG. 23B is a side view of the seal of FIG. 23A showing an instrument passed therethrough;

FIG. 24A is cross-sectional view of one embodiment of a trocar cannula having overlapping scrapers and a sorbent disposed therein;

FIG. 24B is an enlarged view of one of the scrapers and sorbents of FIG. 24A;

FIG. 25 is a perspective view of another embodiment of a scraper for scraping fluid off of a surgical instrument shown passed therethrough;

FIG. 26 is a perspective view of another embodiment of a device for scraping fluid away from a surgical instrument;

FIG. 27A is an exploded view of a trocar and removable tip for scraping fluid away from a surgical instrument;

FIG. 27B is an assembled side view of a distal end of the trocar and removable tip of FIG. 27A;

FIG. 27C is a perspective view of the removable tip and distal end of the trocar of FIG. 26B;

FIG. 28 is a partially-transparent side view of one embodiment of wicking element having an hourglass shape;

FIG. 29 is a perspective view of a trocar having a cannula with slots formed therein for wicking fluid out of the cannula;

FIG. 30A is a perspective view of another embodiment of a trocar having a proximal housing and a distal cannula;

FIG. 30B is a cross-sectional side view of the trocar of FIG. 30A;

FIG. 30C is a perspective view of an instrument seal assembly, a channel seal, a fluid remover assembly, and an insufflation port of the trocar of FIG. 30A;

FIG. 30D is a cross-sectional side view of the fluid remover and insufflation port of FIG. 30C;

FIG. 30E is a perspective view of a fluid remover of FIG. 30C;

FIG. 30F is an exploded view of the fluid remover of FIG. 30E showing a lid, scraper, crown, and sorbent;

FIG. 30G is a bottom perspective view of a scraper of FIG. 30F showing channels formed therein;

FIG. 30H is a cross-sectional view of one of the channels of the scraper of FIG. 30G;

FIG. 30I is a top view of a lid of FIG. 30F;

FIG. 30J is a bottom view of the lid of FIG. 30I; and

FIG. 31 is a bottom view of another embodiment of a lid for use with a fluid remover assembly;

FIG. 32A is a perspective view of another embodiment of a trocar;

FIG. 32B is a side perspective view of an instrument seal, a channel seal, a fluid remover, and an insufflation port of the trocar of FIG. 32A;

FIG. 32C is a side view of the fluid remover and insufflation port of FIG. 32B;



FIG. 32D is a side perspective view of the fluid remover of FIG. 32C;

FIG. 33A is a perspective view of another embodiment of a trocar having a fluid removing system disposed therein;

FIG. 33B is a cross-sectional view of the trocar of FIG. 33A showing an exemplary seal system and fluid removal system;

FIG. 34A is a perspective view of one embodiment of a proximal housing of the trocar of FIG. 33A;

FIG. 34B is another perspective view of the proximal housing of FIG. 34A;

FIG. 35A is a perspective view of one embodiment of a distal housing of the trocar of FIG. 33A;

FIG. 35B is a perspective cross-sectional view of the distal housing of FIG. 35A;

FIG. 36 is an exploded view of the seal system and fluid removal system of the trocar of FIG. 33A;

FIG. 37A is a perspective view of an exemplary seal retainer of the trocar of FIG. 33A;

FIG. 37B is a cross-sectional view of the seal retainer of FIG. 37A;

FIG. 37C is a perspective view of another exemplary seal retainer for use in the trocar of FIG. 33A;

FIG. 38A is a bottom view of an exemplary scraper and wicking element for use in the trocar of FIG. 33A;

FIG. 38B is a top view of the scraper of FIG. 38A;

FIG. 38C is a top view of the scraper of FIG. 38A seated within an exemplary distal housing; and

FIG. 39 is a perspective view of an exemplary sorbent for use in the trocar of FIG. 33A.

#### DETAILED DESCRIPTION OF THE INVENTION

Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those skilled in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

The present invention generally provides methods and devices for maintaining clear visibility through a scoping device during surgical procedures, and in particular methods and devices are provided for removing fluid from an access device and/or surgical instrument passed, e.g., inserted and/or withdrawn, through an access device, and/or for preventing fluid from being transferred onto a scoping device passed through an access device. In certain exemplary embodiments, the methods and devices are effective to remove fluid from an access device and/or surgical instrument as the instrument is being withdrawn from the access device, thus preventing the fluid from being deposited onto an instrument being inserted through the access device. However, the methods and devices can be configured to remove fluid prior to and/or during insertion and/or removal.

A person skilled in the art will appreciate that the term fluid as used herein is intended to include any substance that, when on a surgical instrument, can adversely affect the functioning of the instrument or a surgeon's ability to use it.

Fluids include any kind of bodily fluid, such as blood, and any kind of fluid introduced during a surgical procedure, such as saline. Fluids also include fluid/solid mixtures or fluids with particles (such as pieces of tissue) suspended or located therein, as well as viscous materials and gases. A person skilled in the art will also appreciate that the various concepts disclosed herein can be used with various surgical instruments during various procedures, but in certain exemplary embodiments the present invention is particularly useful during laparoscope procedures, and more particularly during procedures in which a scoping device, such as an laparoscope or endoscope, is passed through a surgical access device, such as a trocar, that provides a pathway from a skin incision to a body cavity. As previously explained, during such procedures repeated insertion and withdrawal of the scoping device can deposit fluid within the access device, thus allowing the fluid to be transferred back onto the distal viewing end of the scoping device upon reinsertion therethrough. Various exemplary methods and devices are provided herein to prevent such an occurrence.

In certain exemplary embodiments, the methods and devices disclosed herein utilize a fluid remover that is effective to remove fluid from an access device and/or surgical instrument passed therethrough. While the fluid remover can have various configurations and it can function in various manners to remove fluid, exemplary fluid removers include scrapers for scraping fluids, sorbents for sorbing fluid, and wicking elements for redirecting or wicking fluid away, e.g., by capillary action. Any combination of fluid removers can be provided, and the fluid removers can be disposed at various locations within an access device to remove fluid from portions of the access device and/or from surgical instruments, such as scoping devices, passed through the access device. The particular location of the fluid remover(s) can depend on the particular configuration of the access device and/or surgical instrument.

In certain exemplary embodiments, the fluid remover can include one or more sorbents. The sorbent can be any insoluble (or at least partially insoluble) material or mixture of materials that are capable of sorbing fluids or taking up fluids through a process of one or both of absorption and adsorption. A sorbent material or element can thus include any one of or combination of absorbent materials and/or elements and adsorbent materials and/or elements. In certain exemplary embodiments, the sorbent is formed from a hydrophilic material and/or includes a hydrophilic material to facilitate fluid receipt. For example, the sorbent can be coated using known coating techniques during manufacturing to render one or more portions of the sorbent hydrophilic. In one embodiment, the sorbent can be formed by an extrusion process in which, for example, the fibers can all extend longitudinally in a direction generally parallel to a longitudinal axis of the cylindrical tube, as shown in FIG. 30F. The fibers will thus form a generally cylindrical, hollow tubular member, which can subsequently be cut to form a plurality of sorbents. A sidewall gap or cut-out can also be made to form a C-shaped sorbent, or the sorbent can be formed to have a C-shaped configuration without the need to make any additional cuts. Exemplary shapes and configurations for the sorbent will be discussed in more detail below. A hydrophilic surfactant can be applied to the sorbent, either prior to or after the sorbent is cut. A person skill in the art will appreciate that a variety of techniques can be used to coat the sorbent or portions thereof with a hydrophilic material and/or to form the sorbent or portions thereof from a hydrophilic material. The particular hydrophilic material used can also vary, and exemplary materials will be



discussed in more detail below with respect to the scraper. The same hydrophilic materials used with the scraper can also or alternatively be used with the sorbent.

In general, sorbents that are absorbents remove fluid through a process of absorption, similar to a sponge, in which a liquid diffuses into the volume and/or structure of the absorbent and becomes a part of that volume and/or structure. For example, the sorbent can pick up and retain a liquid distributed throughout its molecular structure causing the absorbent to swell. The liquid can cause the solid structure to swell 50% or more. Typical absorbents are at least 70% insoluble in excess fluid. Absorbents can have any shape, size, and form known in the art as needed to stand alone and/or fit within, around, or throughout any component of a fluid remover and/or trocar. Certain exemplary embodiments of absorbents include, but are not limited to, comminuted wood pulp fluff, cellulose fibers, polymeric gelling agents, hydrophilic non-wovens, cellulose, sodium polycrylate, cotton, polyethylene terephthalate, polyethylene, polypropylene, polyvinyl chloride, ABS, polyamide, polystyrene, polyvinyl alcohol, polycarbonate, ethylene-methacrylate copolymer, and polyacetal.

Sorbents that are adsorbents, on the other hand, remove fluid through a process of adsorption by retaining a liquid on their surface including pores and capillaries. Liquid accumulates on the surface of an adsorbent by forming a film of molecules or atoms that are retained thereon as a consequence of surface energy. In some embodiments, an adsorbent material can include one or more insoluble materials (or at least partially insoluble) that can be coated by a liquid on their surface. For example, the adsorbent can be a structure formed from insoluble fibers. The structure can be porous, as voids or spaces can be located between the individual fibers. Thus, liquid can accumulate on the surface of the fibers, thereby filling the voids between the fibers. Typical adsorbents will adsorb fluid without swelling more than 50% in excess liquid. Adsorbents can have any shape, size, and form known in the art as needed to stand alone and/or fit within, around, or throughout any component of a fluid remover and/or trocar. In an exemplary embodiment, the adsorbent is molded to have a predetermined shape and size. Certain exemplary adsorbent materials include, but are not limited to, oxygen-containing compounds, carbon-based compounds, and/or polymer based compounds, among others. For example, adsorbent materials can include silica gels, alumina, zeolites, activated carbon, graphite, cellulose, porous polymer matrices, perlite, metal hydroxides, metal oxides, cellulose acetate, -butyrate and -nitrate, polyamide, polysulfone, vinyl polymers, polyesters, polyolefines and PTFE, as well as porous glass or glass ceramics, graphite oxide, polyelectrolyte complexes, alginate gel, etc.

While the fluid removers disclosed herein can be used with various surgical access devices known in the art, in certain exemplary embodiments a trocar is provided having one or more fluid removers disposed therein for removing fluid from portions of the trocar and/or from an instrument, such as a scoping device, passed therethrough. A person skilled in the art will appreciate that a trocar is shown for illustration purposes only, and that virtually any type of access device, including cannulas, ports, etc., can be used. FIGS. 1A-1C illustrate one exemplary embodiment of a trocar 2. As shown, the trocar 2 is generally in the form of a housing 6 having a proximal portion (also referred to herein as a proximal housing) that can house one or more sealing elements and a distal cannula 8 extending distally from the proximal housing 6. The trocar 2 defines a working channel 4 extending therethrough for introducing various

instruments into a body cavity. A number of configurations are available for the proximal housing 6. In the illustrated embodiment, the proximal housing 6 has a generally cylindrical shape with a removable cap portion 5 and an inner sidewall 3. An opening 7 can be formed in the proximal end of the housing 6, such that the opening 7 extends through the removable cap 5 and through the remainder of the housing 6 and is coaxial with the working channel 4 extending through the cannula 8. The cannula 8 can also have various configurations, and can include various features known in the art. In the illustrated embodiment, the cannula 8 has a generally elongate cylindrical shape and includes a series of annular ridges 9 formed on an external surface 10 thereof. The opening 7 extending through the proximal housing 6 and the cannula 8 define the working channel 4 that is sized and configured to receive a surgical instrument. One skilled in the art will appreciate that the housing 6 and the cannula 8 can be formed as a unitary structure or as two separate components that are mated to one another. The housing 6 can also include other features, such as a stop-cock valve 13 for allowing and preventing the passage of an insufflation fluid, e.g. carbon dioxide, through the trocar 2 and into a body cavity.

In use, the distal cannula 8 can be inserted through a skin incision and through tissue to position a distal-most end within a body cavity. The proximal housing 6 can remain external to the body cavity, and various instruments can be inserted through the working channel 4 and into the body cavity. Typically, during surgical procedures in a body cavity, such as the abdomen, insufflation is provided through the trocar 2 to expand the body cavity to facilitate the surgical procedure. Thus, in order to maintain insufflation within the body cavity, most trocars include at least one seal disposed therein to prevent air from escaping. Various seal configurations are known in the art, but typically the trocar 2 includes an instrument seal that forms a seal around an instrument disposed therethrough, but otherwise does not form a seal when no instrument is disposed therethrough; a channel seal (also referred to herein as a zero-closure seal) that seals the working channel 4 when no instrument is disposed therethrough; or a combination instrument seal and channel seal that is effective to both form a seal around an instrument disposed therethrough and to form a seal in the working channel 4 when no instrument is disposed therethrough. In the embodiment shown in FIGS. 1A-1C the trocar 2 includes an instrument seal 14 and a separate channel or zero-closure seal 24. However, a person skilled in the art will appreciate that various other seals known in the art can be used including, for example, flapper valves, gel seals, diaphragm seals, etc.

In an exemplary embodiment, as shown in FIGS. 1C-1E, the instrument seal 14 is generally in the form of a multi-layer conical seal 16 and a multi-layer protective member 18 disposed on a proximal surface 15 of the seal 16. As best shown in FIG. 1E, the multi-layer conical seal 16 can include a series of overlapping seal segments 20 that are assembled in a woven arrangement to provide a complete seal body. The seal segments 20 can be stacked on top of one another or woven together in an overlapping fashion to form the multi-layer seal 16 having a central opening 17 therein. The seal segments 20 can be made from any number of materials known to those skilled in the art, but in an exemplary embodiment the seal segments 20 are formed from an elastomeric material. The seal segments 20 can also be molded such that they have a varying thickness across the profile of the seal 16. Varying the thickness across the profile of the seal 16 can be effective to minimize leakage



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and reduce drag forces on the instrument. The multi-layer protective member **18** can similarly be formed from a series of overlapping segments **22** that are disposed proximal to the overlapping seal segments **20** and that are configured to protect the seal segments **20** from damage caused by surgical instruments passed through the opening **17** in the seal **16**. The protective member **18** can also be formed from various materials, but in certain exemplary embodiments the protective member **18** is formed from a molded thermoplastic polyurethane elastomer, such as Pellethane™. The segments **20**, **22** that form the seal **16** and the protective member **18** can be held together using various techniques known in the art. As shown in FIGS. **1D** and **1E**, the segments **20**, **22** are held together by several ring members that mate to engage the segments **20**, **22** therebetween. In particular, the protective member **18** is engaged between a crown **26** and a gasket ring **28**, and the seal **16** is engaged between the gasket ring **28** and a retainer ring **30**. Pins **32** are used to mate the ring members **26**, **28** and to extend through and engage the segments of the seal **16** and protective member **18**.

When fully assembled, the instrument seal **14** can be disposed at various locations within the trocar **2**. In the illustrated embodiment, the instrument seal **14** is disposed in the cap **5** of the trocar **2** at a location just distal of the proximal opening **7** and proximal of a channel seal, as discussed in more detail below. In use, an instrument can be passed through the center of the seal assembly and the seal segments **20**, **22** can engage and form a seal around an outer surface of the instrument to thereby prevent the passage of fluids through the seal **14**. When no instrument is disposed therethrough, the opening will not form a seal in the working channel **4**, however other configurations in which a seal is formed when no instrument is disposed therethrough are also conceivable. Exemplary instrument seal configurations are described in more detail in U.S. Publication No. 2004/0230161 entitled "Trocar Seal Assembly," filed on Mar. 31, 2004, and U.S. application Ser. No. 10/687,502 entitled "Conical Trocar Seal," filed on Oct. 15, 2003, which are hereby incorporated by reference in their entireties.

The zero-closure seal in the illustrated embodiment is shown in more detail in FIG. **1F**, and as shown the illustrated zero-closure seal is in the form of a duckbill seal **24**. The seal **24** is configured to form a seal in the working channel **4** when no instrument is disposed therethrough to thus prevent the leakage of insufflation gases delivered through the trocar **2** to the body cavity. As shown, the duckbill seal **24** has a generally circular flange **34** with a sidewall **36** extending distally therefrom. The shape of the sidewall **36** can vary, but in the illustrated embodiment, the sidewall **36** includes opposed flaps **35** that extend at an angle toward one another in a distal direction and that come together at a distal end to form a seal face **38**. The opposed flaps **35** are movable relative to one another to allow the seal face **38** to move between a closed position, in which no instrument is disposed therethrough and the seal face **38** seals the working channel **4** of the trocar **2**, and an open position in which an instrument is disposed therethrough. The seal can include various other features, as described in more detail in U.S. application Ser. No. 11/771,263, entitled "Duckbill Seal with Fluid Drainage Feature," filed on Jun. 29, 2007, which is hereby incorporated by reference in its entirety.

In accordance with the present disclosure the general structure of the seals as well as the trocar do not generally form part of the present invention. As such, a person skilled in the art will certainly appreciate that various seal configurations, as well as various trocars, can be used without departing from the spirit of the invention disclosed herein.

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As indicated above, a fluid remover can be disposed within the trocar **2** to remove fluid from a seal and/or from a surgical instrument extending through the seal. As best shown in FIGS. **1B-1C**, the illustrated trocar **2** includes a fluid remover assembly **40** that is disposed within the proximal housing **6** of the trocar **2** at a location distal of the duckbill seal **24**. The fluid removal assembly **40** includes a scraper for scraping fluid off of a surgical instrument passed through the working channel **4** in the trocar **2**, and a sorbent for sorbing removed fluid. The scraper can also include a wicking feature for wicking fluid away from the opening in the scraper, and/or the sorbent can include a wicking feature for wicking fluid away from the scraper.

The components of the fluid remover assembly **40** are shown in more detail in FIGS. **1G-1K**, and as shown the assembly generally includes a lid **42** (FIG. **1K**), a scraper **44** (FIG. **1G**), a sorbent wick **46** (FIG. **1H**), sorbent cartridges **48** (FIG. **1I**), and a housing or frame **50** (FIG. **1J**). When fully assembled, the fluid remover assembly **40** is configured to scrape fluid off of surgical instruments passing through the working channel **4** of the trocar **2**, to wick the scraped fluids away, and to sorb them, thereby preventing the fluids from being redeposited on the instrument upon reinsertion through the working channel.

Referring first to FIG. **1G**, the scraper **44** can have a variety of configurations, but in an exemplary embodiment, as shown, the scraper has a generally planar configuration with a circular shape. A central opening **52** is formed through a central portion thereof and is sized and configured to receive a surgical instrument therethrough. In use, the central opening **52** can be coaxial with openings in the instrument and channel seals. The scraper **44** can be formed from various materials, but in an exemplary embodiment the scraper is formed from polyisoprene to allow the scraper **44** to engage and scrape fluid off of any instrument passed therethrough. As further shown in FIG. **1G**, a distal-facing surface **54** of the scraper **44** can include a plurality of channels **56** formed therein and extending radially outward from the central opening **52**, or from a location just radially outward but adjacent to the central opening **52**. The channels **56** can be configured such that fluid scraped off of an instrument by the central opening **52** will flow into the channels **56** and thereby be wicked away from the opening **52**.

As indicated above, the fluid remover assembly **40** can also include a sorbent wick **46**. As shown in FIG. **1H**, in an exemplary embodiment the sorbent wick **46** has a generally planar circular portion **62** with a central opening **58** formed therethrough. The central opening **58** can have a diameter slightly larger than a diameter of the central opening **52** in the scraper **44**, and it can be configured to be positioned coaxial with the opening **52** in the scraper **44**. As further shown in FIG. **1H**, the sorbent wick **46** can also include one or more sidewalls **60** extending from the planar circular portion **62**. The illustrated sidewalls **60** extend proximally, however they can extend distally depending on the particular configuration of the wick **46**. The sidewalls **60** can be configured to sit within the inner sidewall **3** of the trocar housing **6**. In use, the sorbent wick **46** can wick and sorb fluid away from the central opening **52** in the scraper **44**, and it can deliver the fluid to the sorbent cartridges **48**, as discussed in more detail below. The sorbent wick **46**, as well as various other sorbent members disclosed herein, can be formed from a variety of sorbent materials as described above.

The sorbent cartridges **48** are shown in more detail in FIG. **1I**, and as shown the cartridges **48** each have a generally



semi-circular shape with a width, as measured from an internal surface 64 to an external surface 66, that decreases in a proximal to distal direction to form wedge-shaped members 68. Together, the cartridges 48 can have an annular configuration. In use, the cartridges 48 can sorb fluid from the sorbent wick 46, thereby storing the fluid at a location away from any instrument passed through the working channel 4. The cartridges 48 can be contained within the trocar 2 by a housing or frame 50, as shown in FIG. 1J. The frame 50 can have a generally cylindrical configuration with an opening 68 extending therethrough, and a plurality of ridges 70 protruding radially outward and extending axially along an outer surface 72 thereof. Each sorbent cartridge 48 can be seated between two ridges. In use, the frame 50 can be particularly advantageous as it can protect the sorbent from being contacted by instruments passing through the working channel.

When fully assembly, the scraper 44 can be seated within the sorbent wick 46, which can rest on top of the frame 50 that holds the sorbent cartridges 48. The lid 42, shown in FIG. 1K, can be seated on top of the scraper 44 and within the sorbent wick 46, and the lid 42 can lock onto the frame 50, thereby holding the fluid remover assembly 40 together. Referring to FIG. 1C, the entire assembly 40 can be seated within the proximal housing 6 of the trocar 2 just distal of the duckbill seal 24. As a result, when an instrument, such as a scoping device, is passed through the working channel 4 of the trocar 2, any fluid on the instrument will be scraped off of the sidewalls of the instrument by the scraper 44. The fluid will flow through the channels 56 and/or be wicked away from the opening 52 by the sorbent wick 46, which delivers the fluid to the sorbent cartridges 48. As a result, when the instrument is withdrawn, for example, the fluid will be prevented from being deposited onto the instrument seal 14, thereby preventing the fluid from being transferred from the instrument seal 14 back onto the instrument upon reinsertion.

FIGS. 2A-2B illustrate yet another embodiment of a fluid remover assembly 80 that is similar to the embodiment shown in FIG. 1A. In this embodiment, the proximal housing 79 of the trocar has a frame 82 that is molded into the inner sidewall 81 of the housing 79 for directly seating a sorbent, a scraper, and a lid, thereby eliminating the need for the frame 50 of FIG. 1J. A single sorbent element 86 is also provided, rather than a sorbent wick and separate sorbent cartridges. In particular, the sorbent element 86 in this embodiment has a generally cylindrical configuration with a distal portion 88 that tapers inward on an outer surface 87 thereof to conform to the inner surface 81 of the proximal housing 79 of the trocar. A recess 90 can be formed around an inner surface 92 of a proximal end 93 of the sorbent element 86 to seat a scraper 94, which can have a configuration that is the same as or similar to the scraper 44 described above with respect to FIG. 1G. The recess 90 can engage an outer perimeter 96 of the scraper 94 such that the channels 56 on the scraper 94 can deliver fluid away from the opening 52 in the scraper 94 to the sorbent element 86 surrounding the scraper 94. A cap 98 can sit on top of the scraper 94 and can include a flange 99 that extends around the proximal end 93 of the sorbent element 86. The cap 98 can engage the inner sidewall 81 of the proximal housing 79 of the trocar to retain the scraper 94 and sorbent element 86 therein at a location just distal of the duckbill seal 24. In use, instruments passed through the working channel 4 of the trocar will be engaged by the scraper 94, which scrapes fluid off of the outer surface of the instrument. The fluid is wicked away from the opening 52 in the scraper 94 by the channels

56, which deliver the fluid to the sorbent element 86 surrounding the scraper 94. Thus, similar to the embodiment of FIG. 1A, when the instrument is withdrawn, for example, the fluid will be prevented from being deposited onto the seals, and in particular the instrument seal 14, thereby preventing the fluid from being transferred from the instrument seal 14 back onto the instrument upon reinsertion.

A person skilled in the art will appreciate that the fluid remover assemblies 40, 80 can have a variety of other configurations. FIGS. 3A-10B illustrate additional exemplary embodiments of fluid removers, e.g., scrapers, sorbents, and wicking elements, or combinations thereof. In these embodiments, the fluid removers are all located distal of the channel seal, e.g., duckbill seal or other zero-closure seal, and distal of the instrument seal 14. However a person skilled in the art will appreciate that the particular location of the fluid remover can vary and the fluid removers can be positioned anywhere within the trocar.

FIGS. 3A-3C illustrate one embodiment of a fluid remover assembly 100 having a scraper and a sorbent. In particular, as best shown in FIG. 3B, the fluid remover assembly 100 can include a stabilization cup 106 coupled to a flange 108. The stabilization cup 106 can be formed from a sorbent material and the flange 108 can seat the cup 106 within the proximal housing 6 of the trocar 2, as shown in FIG. 3C. A scraper element in the form of a scraper disc 102 can be positioned between the flange 108 and the stabilization cup 106, and a sorbent ring 104 can be coupled to a distal surface 103 of the scraper disc 102. The scraper disc 102 can have a central opening 105 extending therethrough and configured for scraping fluid off of surgical instruments passed through the working channel 4 of the trocar 2. As an instrument is passed through the working channel 4, fluid can be scraped by the scraper disc 102 and sorbed by the sorbent ring, as well as by the stabilization cup. As can be seen in FIG. 3B, the flange 108, scraper disc 102, and sorbent ring 104 can each optionally include cut-outs 110 to fit around the stop-cock 13 associated with the trocar 2. In use, the fluid remover assembly 100 can be formed as a drop-in unit that fits within the proximal housing 6 of the trocar 2. As shown in FIG. 3C, the assembly 100 can be seated in a distal portion of the proximal housing 6 at a location just distal of the duckbill seal 24. The fluid remover assembly 100 will thus remove fluid from instruments passed through the working channel 4 of the trocar, thereby preventing fluid from being deposited onto the seals, and in particular the instrument seal 14, and/or redeposited onto instruments passed through the working channel 4.

FIGS. 4A-4C illustrate another embodiment of a fluid remover assembly 114 that is similar to the assembly shown in FIGS. 3A-3C, however in this embodiment the assembly 114 does not include a stabilization cup. As shown, the fluid remover assembly includes a substantially planar circular scraper disc 116 having a central opening 115 for receiving a surgical instrument. The scraper disc 116 can be seated within a flange or retainer ring 118 configured to be positioned within the proximal housing of a trocar. A sorbent ring 120 can be positioned adjacent to a distal surface 117 of the scraper disc 116 and it can act to sorb any fluid that is scraped off of instruments passed through the scraper disc 116. When disposed within a trocar, the flange 118 can act as a support structure to hold the scraper disc 116 and the sorbent ring 120 in a fixed position within the proximal housing. While the position can be distal to the duckbill seal, as indicated above the assembly can be located at various other portions within the trocar, including between the



duckbill seal and the instrument seal, proximal to the instrument seal, or within any portion of the cannula.

In another embodiment, shown in FIGS. 5A-5C, a fluid remover assembly **122** is provided and can have a generally conical configuration with a scraper **124** having a proximal generally planar flange **125** and a conical body **126** extending distally therefrom and defining a central opening **128**. The conical body **126** can have a plurality of slits **127** extending proximally from a distal end thereof and designed to reduce insertion and withdrawal forces on a surgical instrument passed therethrough. The conical body **126** can be surrounded by a conical sorbent element **130** such that the conical body **126** is nested within the conical sorbent element **130**. When assembled and disposed within a trocar, as shown in FIG. 5C, the flange **125** can be seated within the proximal housing **6** just below the duckbill seal **24** and it can mate to or engage the inner sidewall of the housing **6** to retain the fluid remover assembly therein. In use, as an instrument is passed through the working channel, the scraper **124** can engage and scrap fluid off of the instrument and the sorbent element **130** can sorb the fluid. A person skilled in the art will appreciate that any number of geometries can be used in a similar way. Also, a size or diameter of a flange can be adjusted as needed, or the flange can be removed, to seat the fluid remover assembly at other locations within the trocar.

FIGS. 6A-6C illustrate additional embodiments of conical scrapers **132a**, **132b**, **132c** that are similar to the scraper **124** described above and shown in FIGS. 5A-5C. As with the previous embodiment, the scrapers **132a**, **132b**, **132c** in FIGS. 6A-6C are positioned distal to the duckbill seal **24**. Such a configuration can prevent fluid on instruments being inserted and/or withdrawn from being deposited onto the duckbill seal, as well as the more-proximally located instrument seal **14**. In an exemplary embodiment, each scraper **132a**, **132b**, **132c** can be made from a pliable material and can include at least one slit formed therein and configured to allow the scrapers **132a**, **132b**, **132c** to radially expand. A variety of configurations are available for the slit(s). In the embodiment shown in FIG. 6A, a single slit **134** extends diagonally around the scraper **132a** such that the slit **134** follows the shape of the cone. In another embodiment shown in FIG. 6B, multiple slits **137** extend proximally from the distal end of the cone and terminate at a location **139** just distal to the proximal end. Such a configuration can yield a scraper having multiple scraping segments **138**. As further shown in FIG. 6B, each scraping segment **138** can also include a notch or cut-out **140** formed in an outer surface at the distal end thereof to allow the segment **138** to expand and contact as instruments are passed therethrough. FIG. 6C illustrates another exemplary embodiment of a cone shaped scraper **132c**. Similar to the scraper **132b** shown in FIG. 6B, the scraper **132c** includes several slits **142** that extend proximally from the distal end thereof. In this embodiment, however, the slits **142** increase in width in a distal to proximal direction such that each scraping segment **143** has a distal end **144** with a width that is greater than a width of a proximal end **145** thereof. As indicated above, in use the slit(s) **134**, **137**, **142** formed in the scrapers **132a**, **132b**, **132c** allow the scrapers to radially expand as a surgical instrument is passed therethrough, thus accommodating instruments of various sizes while still being effective to scrape fluid off of the instruments.

FIG. 7 illustrates another embodiment of a fluid remover positioned just distal of a channel seal, e.g., duckbill seal **150**, in a proximal housing of a trocar. In this embodiment, the fluid remover is in the form of sorbent flapper doors **152**.

The flapper doors **152** can have various shapes and sizes, and they can be formed from any number of components. For example, the flapper doors **152** can be in the form of two sidewalls **153** that are movable relative to one another. The sidewalls **153** can have a profile that is similar to the profile of the duckbill seal **150**. In other embodiments, the flapper doors **152** can have a shape that corresponds to the shape of the duckbill seal **150**. A person skilled in the art will appreciate that various configurations are possible. The flapper doors **152** can be seated inside the proximal housing **6** and attached to the housing **6** by any attachment means known in the art, including by mechanical means, adhesives, etc. The flapper doors **152** can define an opening **154** therebetween for receiving a surgical instrument, and the opening **154** can be positioned just distal of the seal face **151**. In use, the flapper doors **152** can move from a closed or substantially closed position to an open position as an instrument is passed through the duckbill seal **150** and the flappers door **152**. The doors **152** can contact and engage the surgical instrument as it is being passed therethrough to sorb fluids off of the instrument. The flapper doors **152** can also sorb any excess fluid that is scraped off of the instrument by the duckbill seal **150** and that falls distally from the duckbill seal **150**.

In a similar embodiment, shown in FIG. 8, the fluid remover can be in the form of a wicking element rather than a sorbent. In the illustrated embodiment, the wicking element is in the form of first and second wicking fingers **160a**, **160b** that are coupled to opposed outer edges **162** of the seal face **161** on the duckbill seal **163**. The wicking fingers **160a**, **160b** can be in the form of elongate members that follow the natural shape of the inner sidewall **165** of the proximal housing **6** of the trocar **2** so that fluid will run naturally down the fingers **160a**, **160b**. The wicking fingers **160a**, **160b** can also include a sorbent reservoir **164** disposed on a distal end thereof. In the illustrated embodiment, the sorbent reservoir **164** on each finger **160a**, **160b** is in the shape of ring seated within the proximal housing **6** and effective to sorb the fluids wicked away from the duckbill seal **163** by the wicking fingers **160a**, **160b**. The sorbent reservoir **164** can, however, have various other configurations such as ring segments. In use, as fluids are deposited on the duckbill seal **163** by instruments passing therethrough, the fluid will naturally flow to outer corners or edges of the seal face **161**. The surface difference between the wicking fingers **160a**, **160b** and the duckbill seal **24** will cause fluid to flow from the seal **163** to the fingers **160a**, **160b** and down the fingers **160a**, **160b** into the sorbent reservoir **164**. As will be appreciated by those skilled in the art, the wicking fingers **160a**, **160b** can be formed integrally with the duckbill seal **163** or can simply be in close contact with sealing face **161** of the duckbill seal **163**.

FIG. 9 illustrates another embodiment of a fluid remover that is positioned distal of a zero-closure seal. Similar to the embodiment shown in FIG. 7, the fluid remover is in the form of a sorbent. However, in this embodiment the sorbent is a sorbent grommet **172**. The grommet **172** can have a generally circular or conical configuration with an opening **173** formed therethrough, as shown, but it can have any number of other geometries to facilitate passage of an instrument therethrough. The grommet **172** can also include multiple slits **174** formed therein and extending radially outward from the opening **173** to reduce insertion and withdrawal forces on an instrument being passed therethrough. In use, the grommet **172** can be seated within a distal portion of the proximal housing **6** of the trocar, just distal of the duckbill seal **166**, and the opening **173** can be



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positioned coaxial with the working channel 4. As a surgical instrument is passed therethrough, the grommet 172 will contact the instrument and sorb any fluid on the instrument. The grommet 172 can also sorb any fluid that drips off of the duckbill seal 166 as the seal 166 scrapes the instrument.

In other embodiments, the zero-closure seal itself can be modified to include a fluid remover. For example, FIGS. 10A and 10B illustrate another embodiment of a duckbill seal 176 in which the seal face 168 is extended distally and expanded in width to cause the outer ends of the seal face 168 to contact the inner sidewall 169 of the proximal housing 6 of the trocar, thereby forming a wicking element. In use, when an instrument is passed through the duckbill seal 176, the seal face 168 will scrape fluid off of the instrument. The fluid will naturally run outward toward the outer-most edges of the seal face 168. Since the outer edges are in contact with the inner sidewall 169 of the proximal housing 6, the fluid will be wicked away from the seal face 168 and onto the inner sidewall 169 of the housing 6. While not shown, the housing 6 can optionally include a sorbent disposed therein for sorbing the fluid wicked away from the seal.

FIG. 11 illustrates another embodiment of a modified zero-closure seal 186. In this embodiment, a sorbent element 180 is nested inside of the duckbill seal 177, and a second duckbill seal 178 is nested within the sorbent element 180. The nested sorbent 180 and the nested duckbill seal 178 can have two sealing walls, 182, 184 similar to the duckbill seal 177, that meet at a seal face that is configured to form a seal when no instrument is disposed therein and that are configured to open when a surgical instrument is passed therethrough. The body of the nested sorbent 180 and the nested duckbill 178 can each have a profile similar or identical to the duckbill seal 177, except smaller in size to all fit for a nested configuration. The components 177, 178, 180 can merely be seated within one another, or they can be attached to one another using various attachment mechanisms known in the art, including a press fit, glue, etc. In use, the seal face of all three components will contact a surgical instrument as it is passed through the seal assembly. The sorbent 180 will thus sorb any fluid on the instrument, as well as fluid scraped off of the instrument by the duckbill seal 177 and the nested duckbill seal 178.

FIGS. 12A-12B illustrate another embodiment of a modified zero-closure seal 190. In this embodiment, the duckbill seal 191 includes two sorbent bars 192 disposed therein and extending thereacross. The sorbent bars 192 can be positioned to extend substantially parallel to the seal face 193, or to extend substantially perpendicular as shown. The seal 190 can also include a sorbent ring 194 positioned around an inner sidewall 193 of the duckbill seal 191 and in contact with the sorbent bars 192. The sorbent ring 194 can provide a reservoir for fluid collected by the sorbent bars 192. In use, the sorbent bars 192 will contact and engage a surgical instrument as it is passed through the duckbill seal 191, and will thus sorb fluid away from the surgical instrument.

As indicated above, the various fluid remover embodiments disclosed herein can be located anywhere within a trocar or other access device, including distal of a channel seal, between a channel seal and an instrument seal, or proximal of an instrument seal. The position of the fluid remover can also vary relative to an insufflation port, as will be discussed in more detail below. The fluid removers can also be formed integrally with the seal(s) and/or portions of the housing, and any combination of fluid removers can be used. FIGS. 13-22B illustrate various exemplary embodiments of fluid removers that are formed integrally or incor-

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porated into an instrument seal, or located adjacent to an instrument seal and thus proximal to a channel seal.

Turning first to FIG. 13, in this embodiment the fluid remover 200 is in the form of a combination scraper and sorbent. In particular, the fluid remover 200 includes a generally planar circular scraper disc 202 having an opening 204 formed therethrough and configuration to be positioned coaxial with the working channel 4 in the trocar 2. The opening 204 can be sized and configured to form a seal around an instrument passed therethrough. The fluid remover 200 can also include a sorbent disk 206 disposed concentrically around the opening 204 in the scraper 202. In use, the scraper 202 will scrape fluid off of instruments passed therethrough, and the sorbent disk 206 will sorb the scraped fluid. The fluid remover 200 can be disposed within the proximal housing 6 of the trocar 2 using various techniques, but as shown in FIG. 13 the fluid remover 200 is configured to be engaged between the removable cap 5 and the distal portion of the proximal housing 6 of the trocar 2. As a result, the scraper 202 and sorbent 206 will be positioned in alignment with the working channel 4 extending through the housing 6, and will also be positioned between the proximal instrument seal and the distal channel seal.

FIG. 14 illustrates another embodiment of a fluid remover 210 having a combination scraper and sorbent, however in this embodiment the fluid remover 210 is fully disposed within the removable cap 5 containing the instrument seal. As shown, a scraper 212 can be cone shaped and can be positioned just distal of the instrument seal. In other embodiments the scraper 212 can be planar. The scraper 212 can also replace or function as the instrument seal. A sorbent ring 214 can be positioned concentrically around and in contact with an opening 216 in the distal end of the of the conical scraper 212. As a result, the sorbent ring 214 will sorb any fluid scraped away from a surgical instrument extending through the scraper 212.

In yet another embodiment, shown in FIGS. 15A and 15B, the fluid remover can be in the form of a scraper that is part of the instrument seal 218. As shown, the instrument seal 218 is a multi-layer seal having the protector disposed on a proximal surface thereof, as previously described with respect to FIG. 1E. The scraper can be in the form of a second protector 222 that is disposed distal to the multi-layer seal segments. The second protector 222 can have the same configuration as the protector of FIG. 1E, however the second protector 222 can define an opening 224 that is configured to contact and engage a surgical instrument passed through the seal 218. Accordingly, in use, the second protector 222 can engage and scrape fluid away from instruments passed through the seal 218.

In another embodiment, shown in FIG. 16, the fluid remover can be in the form of a multi-layer sorbent that is positioned between the multiple layers 20 of the seal 16, as shown, or that is positioned between the multiple layers 22 of the seal protector 18. The sorbent can be in the form of multiple sorbent sheets 232 that are layered in between the layers of the seal 16 (or seal protector 18). Thus, in use, when an instrument is passed through the instrument seal, the sheets 232 will sorb any fluids scraped off of the instrument by the seal 14, thereby preventing fluid from accumulating around the opening of the seal 14 and being reapplied to a surgical instrument as it is reinserted therethrough. The sorbent sheets 232 can be effective to sorb fluid, as well as to interrupt surface tension and/or capillary action between the seal and the protector. Thus, there should



be no fluid in or near the seal opening and/or protector opening that will be able to touch or collect on an instrument being passed therethrough.

FIG. 17 illustrates another embodiment of a sorbent fluid remover. In this embodiment, the sorbent is in the form of a grommet 242 having a configuration similar to the grommet 172 previously described with respect to FIG. 9. However, in this embodiment the grommet 242 is positioned adjacent to a distal surface 244 of the instrument seal 14, rather than the zero-closure seal 24. In particular, as shown in FIG. 17, the grommet 242 can be disposed concentrically around a distal opening 246 formed in the removable cap 5 such that instruments passed through the instrument seal 14 will contact the grommet 242, which will sorb fluids off of the instrument. The grommet 242 can also sorb any fluid that is scraped from or drips from the instrument seal 14.

In another embodiment shown in FIGS. 18A and 18B, a wicking element is formed integrally with the multi-layer seal protector 18 previously described with respect to FIG. 1E. As previously explained, the multi-layer seal 16 can have a natural shape that is slightly conical and it can include an opening sized to receive an instrument therethrough. The protector 18 likewise has an opening, however in the embodiment shown in FIGS. 18A and 18B the length of a protector 240 is decreased to thereby increase the diameter of the opening defined by the protector 18. As a result, the protector 240 will have an opening that is larger than the opening in the seal 16 to create a flattened profile against the conical shape of the seal 16, thereby creating a gap between the protector 240 and seal 16. As surgical instruments are removed from the trocar, the gap will prevent fluids from collecting between the layers 20 of the seal 16 and will allow the protector 240 to wick fluids away from the opening of the seal 16. Thus, if fluid is deposited on the seal 16, there will be no capillary action to hold the fluid between the seal 16 and the protector 240, thereby allowing the fluids to drain. In addition, when an instrument is passed through the protector 240 and seal 16, the gap created between the seal 16 and protector 18 will prevent fluid from being squeezed from between the seal 16 and protector 240 and onto an instrument.

In another embodiment shown in FIGS. 19A and 19B, the multi-layer seal protector 248 has a wicking element in the form of camming ribs 250 disposed on a surface of each individual protector layer 249 so that the ribs 250 create pockets between the layers for wicking away and retaining fluid scraped off of instruments by the instrument seal. In the illustrated embodiment, the ribs 250 are offset by 90 degrees, although other geometries are possible as will be appreciated by those skilled in the art. In one embodiment, the ribs 250 can be disposed on a top or proximal surface of the protector. Thus, as a surgical instrument is passed through the instrument seal 14, the instrument will contact the ribs 250 to thereby cam open the protector 248 and the seal, preventing the surgical instrument from coming into contact with the surface of the protector 248 and/or the seal. In another embodiment, the ribs 250 can be disposed on a bottom or distal surface of the protector, thereby creating a gap between the protector 248 and the seal to prevent capillary action and the trapping of fluid between the seal and protector 248.

FIGS. 20A and 20B illustrate another embodiment of an instrument seal 254 having ribs for wicking fluid away from an opening in the seal 254. In this embodiment, the instrument seal 254 is in the form of a deep cone seal having a flange 260 with a conical sidewall 262 extending distally therefrom. A distal portion 264 of the conical sidewall 262

tapers inward to define an opening 258 in the distal end 264 of the seal 254. In the embodiment shown in FIG. 20A, the sidewall 262 can include one or more ribs 266 formed on an external surface 261 thereof and extending between proximal and distal ends of the sidewall 262, terminating at the opening 258. The external ribs 266 can be effective to wick fluid away from the opening 258 in the seal 254. In the embodiment shown in FIG. 20B, the ribs 266 are formed on the inner surface 268 of the sidewall 262 and extend between proximal and distal ends of the sidewall 262, terminating at the opening 258. The ribs 266 will thus have a camming effect, causing any instrument inserted through the seal 254 to contact the ribs 266 to cam open the seal 254, rather than contacting an inner surface 268 of the seal 254.

In another embodiment, shown in FIG. 21, the multi-layer seal protector 269 can include a plurality of holes 270 formed in the individual layers 271 of the protector 269 to form a wicking element for wicking fluid away from the seal. As fluid is trapped between the protector 269 and the seal when an instrument is passed through the instrument seal, the holes 270 act to wick away fluid from the seal and from the opening in the seal. The fluid can be retained within the holes 270 by surface tension so that an instrument passed through the seal will not contact the fluid retained in the holes 270.

Various other modifications can also be made to the multi-layer seal protector previously described in FIG. 1E to remove fluid from the seal or from instruments passed through the seal. In another embodiment, shown in FIGS. 22A and 22B, the protector segments 272 can include surface features, such as a roughened surface 276, formed on the distal surface thereof. As shown in FIG. 22B, when the protector segments 272 are positioned against the seal segments 20, the roughened surface 276 will create a gap that separates the protector 273 from the seal, thus providing a path for fluid to wick away from the opening in the seal and from between the protector 273 and the seal.

FIGS. 23A-23B illustrate another embodiment of a seal 280 that is configured to remove fluid. In this embodiment, the seal 280 has an hourglass configuration such that the seal 280 is a combination trocar and instrument seal. In other words, the seal 280 is effective to both form a seal within the working channel of the trocar when no instrument is disposed therethrough and to form a seal around an instrument disposed therethrough. The hourglass shape of the seal 280 allows a central portion 282 of the seal 280, which in a natural state is in a closed configuration as shown in FIG. 23A, to open and engage an instrument passed therethrough, as shown in FIG. 23B, and thereby scrape any fluid off of the instrument. Due to the curvature in inner sidewalls 284 of the seal 280, the removed fluid will flow away from the central portion thus preventing the fluid from being redeposited onto an instrument reinserted therethrough. The hourglass configuration of the seal 280 is also advantageous in that it will accommodate instruments of various sizes. The central portion 282 can also move or float relative to the central axis of the working channel in the trocar, thus accommodating off-axis instruments.

FIGS. 24A-29 illustrate various other exemplary embodiments of fluid removers. While certain embodiments are described as being disposed or formed in the cannula, a person skilled in the art will appreciate that, as with previous embodiments, the embodiments of FIGS. 24A-29 can likewise be disposed at various locations within a trocar and that various combinations of fluid removers can be used.

In the embodiment shown in FIGS. 24A and 24B, the fluid remover is in the form of a plurality of scraper elements that



extend at least partially across the working channel **4** of the cannula **8**. The scraper elements can be relatively thin and can take the shape and form of wipers **292**, as best shown in FIG. **24B**, that will scrape or squeegee fluid off of a surgical instrument passed through the cannula **8**. The wipers **292** can be fixedly or hingedly coupled to an inner sidewall **294** of the cannula **8**, and they can be flexible to accommodate instruments of various sizes, and to allow both insertion and withdrawal of the instruments. The cannula **8** can also include any number of wipers **292**, and the wipers **292** can be spaced apart from one another, or they can be in a stacked configuration. The wipers **292** can have a conical configuration such that each wiper **292** extends around the entire inner diameter of the cannula **8**. Alternatively, the wipers **292** can be formed into individual segments that are positioned a distance apart from one another, e.g., approximately 90 degrees apart within the interior surface **294** of the cannula **8**. The segments can be layered within the cannula **8** so that different parts of the surgical instrument come into contact with the wipers **292** at different heights as the instrument is being passed therethrough. The wipers **292** can also be in contact with a sorbent element **296**, or include a sorbent portion, such that the collected fluid drips onto or is wicked into the sorbent material and away from possible contact with a reinserted instrument. As shown in FIGS. **24A-24B**, the sorbent element **296** is located adjacent to the inner sidewall **294**, and thus radially outward from the wiper body **292**. The sorbent elements **296** can be formed into a wall of the cannula **8**, so that the cannula **8** is partially formed from the sorbent elements **296**. The sorbent elements **296** can also be formed within grooves in the cannula wall and/or can be adhered directly to the cannula wall by any attachment mechanism known in the art, for example an attachment ring **297**. In use, as an instrument is passed through the cannula **8**, the instrument will be scraped on all sides simultaneously by the plurality of wipers **292**. The fluid will flow outward where it will be sorbed by the sorbent element **296**.

FIG. **25** illustrates another exemplary embodiment of a scraper **300**. In this embodiment, the scraper **300** is substantially cone shaped increasing in diameter in a distal direction. A proximal end **302** of the scraper **300** includes an opening **304** formed therethrough, and a fluid collection member is formed at a distal end **306** thereof and extends inwardly. The fluid collection member can have a variety of configurations and can be generally configured to collect fluid scraped by the scraper **300**. In one exemplary embodiment, as shown, the fluid collection member can be in the form of a substantially C-shaped lip **308** extending inwardly from the distal end **306** of the scraper **300**. At least a portion of the fluid collection member can also optionally be sorbent thereby enabling the fluid collection member to both collect and sorb fluid scraped by the scraper. The scraper **300** can be formed from a pliable material such that it can radially expand to engage a surgical instrument extending therethrough. In use, the narrow proximal end of the scraper **300** can engage a surgical instrument passed therethrough to thereby scrape fluid away from the instrument. The fluid scraped away from the instrument will run down an inner surface **310** of the scraper **300** and be collected and/or sorbed by the fluid collection member disposed at the distal end **306** of the scraper **300**. While the scraper **300** is generally indicated as being disposed in the cannula **8**, the scraper **300** can likewise be disposed anywhere within the trocar **2**, including in the proximal housing **6**.

FIG. **26** illustrates another exemplary embodiment of a scraper **312**. In this embodiment, the scraper **312** includes

first and second rotatable members **314a**, **314b** that are configured to rotate and engage a surgical instrument as the instrument is passed therethrough. The first and second rotatable members **314a**, **314b** can have a variety of shapes and sizes. In the illustrated embodiment, the first and second rotatable members **314a**, **314b** are spool shaped. The spools can be configured such that the geometry of second member **314b** complements that of the first member **314a**. As shown, the first member **314a** includes a substantially spherically shaped central portion **316** that corresponds with a concave cut-out **318** in the second member **314b**. The geometry of the spools can have several shapes including, but not limited to, straight sided cylindrical, c-shaped, and indented cylindrical. The first and second rotatable members **314a**, **314b** can be positioned at a variety of locations in the cannula, or within the proximal housing of a trocar, and they can be formed from a variety of materials including, but not limited to, rigid, pliable, and sorbent materials. In use, the rotatable members **314a**, **314b** can rotate and engage a surgical instrument passed therethrough to thereby scrape and optionally sorb fluid away from the instrument.

FIGS. **27A-27C** illustrate another embodiment of a fluid remover in the form of a removable tip or sleeve **322** that can be removably coupled to a distal end **324** of the cannula **8**. As shown, the sleeve **322** is in the form of a generally cylindrical housing with a tapered distal end **326**, similar to the distal end **324** of the cannula **8**. A proximal end **328** of the sleeve **322** can be sized to fit over and engage the distal end of the cannula **8**, e.g., by interference fit, and the distal end of the housing can include an opening **330** formed therein and sized to receive a surgical instrument therethrough. The sleeve **322**, or at least a portion of the sleeve **322** surrounding the opening **330** at the distal end **326**, can be formed from a compliant or expandable material to allow the opening in the sleeve **322** to radially expand as an instrument is passed therethrough. Exemplary compliant materials include, but are not limited to, polyisoprene, pellathane, and silicone. In use, as a surgical instrument is passed through the opening **330** in the sleeve **322**, the opening **330** will scrape fluid off of the instrument, thereby preventing the fluid from being dragged into the trocar and deposited on the seals.

In another embodiment shown in FIG. **28**, an hourglass shaped seal **340**, similar to the seal **280** described with respect to FIGS. **23A-23B** is provided, however the seal **340** includes a wicking element in the form of one or more cut-outs or slots **342** formed in the central, reduced-diameter portion **344**. Similar to the seal **280** previously described with respect to FIGS. **23A** and **23B**, the hourglass shape will allow the central portion **344** to scrape or squeegee fluid from a surgical instrument passed therethrough. The cut-outs or slots **342** will allow the scraped fluid to be wicked through the slots **342** to an exterior surface **346** of the seal **340**.

In another embodiment shown in FIG. **29**, the wicking element can take the form of a plurality of slots **350** formed in the working channel **4** of a cannula **352**. The slots **350** can have any size and shape sufficient to transfer fluid disposed on an inner surface of the cannula **352** to an outside surface **354** of the cannula **352**. Thus, as an instrument is passed through the cannula **352**, any fluid that drips down the inner surface of the cannula **352** will be transferred to the external surface **354** of the cannula **352** through the slots **350**.

FIGS. **30A-30J** illustrate another embodiment of a trocar **400** having a fluid remover **430** disposed therein. As shown, the trocar **400** has a proximal housing **402** and a distal cannula **404** with a working channel **408** formed through and extending between proximal and distal ends **400a**, **400b**



thereof. The housing **402** can include one or more seals that are effective to seal the working channel **408**, i.e., to prevent the escape of insufflation, when no instrument is disposed therethrough and/or when an instrument is disposed there-  
 through. As shown in FIGS. **30B** and **30C**, the housing **402** 5 includes a proximal instrument seal, in the form of a multi-layer seal **412**, that is effective to form a seal around an instrument inserted therethrough, and a distal channel seal, such as a duckbill seal **410**, that is effective to seal the working channel when no instrument is inserted there-  
 through. One exemplary embodiment of a duckbill seal **410** 10 that can be used with the present invention is disclosed in U.S. patent application Ser. No. 11/771,263 filed on Jun. 29, 2007 and entitled "Duckbill Seal With Fluid Drainage Feature," by Paul T. Franer and Thomas A. Gilker. Such a duckbill is particularly useful as it has a low profile and has fluid drainage features that can assist in further preventing fluid from being redeposited onto instruments inserted  
 through the seals. A person skilled in the art will appreciate that any number, type, and configuration of channel and/or 20 instrument seals can be positioned within the housing **402** at various locations. The housing can also include an insufflation port **406** is formed in the housing **402** for providing an insufflation gas to the working channel **408**.

As indicated above, the housing **402** can include a fluid 25 remover **430** positioned therein and configured to remove fluid from a surgical instrument inserted therethrough. The fluid remover **430** can have an opening **470** formed through a center portion thereof, in axial alignment with the working channel **408**, for receiving a surgical instrument. The open-  
 ing **470** can be effective to remove fluid from a surgical instrument upon insertion and/or withdrawal therethrough. In an exemplary embodiment, the fluid remover **430** is  
 preferably positioned distal to the seals **412**, **410** so that fluid 30 collected on the instrument when disposed in a body cavity can be removed from the surgical instrument before it is withdrawn through the seals **412**, **410**, thus preventing the fluid from being deposited on the seals and thereafter deposited onto an instrument inserted into the trocar. In  
 order to position the fluid remover **430** distal to the seals **412**, **410**, the fluid remover **430** will positioned proximal to, 40 distal to, or in the path of the insufflation port. Where the fluid remover **430** is positioned in the path of or distal to the insufflation port, it is preferably configured so that it does not block the path of an insufflation gas from the port  
 through the distal cannula **404**. During many surgical pro- 45 cedures using a trocar, insufflation is used to expand the body cavity into which the trocar extends. Trocars can thus have an insufflation port, such as the port **406** shown in FIGS. **30A-30C**, that is positioned distal to the seals **412**,  
**410** so that the seals are effective to prevent gas from 50 flowing out of the proximal housing **402**. In this way, a constant flow of gas is maintained through the distal cannula **404** and into the body cavity. Since the port **406** is positioned distal to the seals **412**, **410**, in an exemplary embodiment, in  
 order to maintain a low profile housing and position the fluid 55 remover **430** distal of the seals, the fluid remover **430** can be positioned adjacent to or distal to the port **406**. As such, the fluid remover **430** is preferably configured to allow air to pass therethrough and/or therearound such that it does not  
 block the flow of insufflation gas from the port **406** to the 60 cannula **404** when an instrument is inserted through the opening **470** in the fluid remover **430**. In other words, the fluid remover **430** can have a configuration that allows the passage of insufflation gas from the port **406** to the distal  
 cannula **404** even when an instrument is disposed through 65 the fluid remover **430**. FIGS. **30A-30J** illustrate one such

embodiment of the fluid remover **430** that is in the pathway of the flow of gas from the port **406** to the cannula **404**. In this embodiment, a cut-out or pathway is provided in a portion of the fluid remover **430** to allow the passage of gas  
 therethrough from the port **406** to the cannula **404**, as will be 5 discussed in more detail below. The fluid remover **430** can also include other features to facilitate the passage of gas therethrough, as will be discussed in more detail below.

The fluid remover **430** can have various configurations 10 and it can include any one or more of a wicking element, a sorbent, and a scraper. FIGS. **30C-30F** illustrate one embodiment of the fluid remover **430** that is positioned distal to the seals **412**, **410** and in proximity to the insufflation port **406**. The fluid remover **430** generally includes a  
 sorbent **414** disposed within the housing and disposed 15 around a crown **420**, a scraper **422** positioned on a proximal surface of the crown **420**, and a lid **418** positioned against a proximal surface of the scraper **422**.

As shown in more detail in FIGS. **30F** and **30G**, the 20 scraper **422** of the fluid remover **430** can have many shapes and configurations, but in the illustrated embodiment the scraper **422** is disc shaped and has an opening **424** formed through a center portion thereof. The scraper **422** can be configured to remove fluid from a surgical instrument pass-  
 ing through the opening **424** by contacting the surgical 25 instrument and scraping and/or squeegeeing its circumference. In an exemplary embodiment, the scraper **422** is formed from a flexible and resilient material to allow the opening **424** of the scraper **422** to expand around and engage  
 an outer wall of an instrument passed therethrough. 30

The scraper **422** can also include features to direct fluid 35 flow. For example, as shown in FIG. **30G**, the scraper can include one or more channels **422c** formed in a distal surface thereof and extending radially outward from the opening **424** such that fluid scraped off of an instrument being  
 withdrawn through the opening **424** will flow through the 40 channels and radially away from the opening **424**. As further shown in FIGS. **30F** and **30G**, the scraper **422** can also include one or more holes **422h** formed therethrough for receiving pins formed on the crown **420**, as will be discussed  
 in more detail below. The holes **422h** allow the scraper **422** 45 to rest on a proximal surface of the crown **420** and to be captured between the crown **420** and the lid **418**. The holes **422h** can also have a size that allows air to pass therethrough when the pins of the crown **420** are disposed therein. Such  
 a configuration can assist in preventing the fluid remover 50 **430** from functioning as a seal, as will be discussed in more detail below. In some embodiments, however, the scraper **422** can also be formed as an instrument seal and/or as a scraper for smaller diameter surgical instruments and a seal  
 for larger diameter surgical instruments.

In certain exemplary embodiments, in order for the 55 scraper **422** to effectively wick fluid radially outward from the opening and toward the sorbent, all or portions of the scraper can be formed from or can include a hydrophilic material. For example, the scraper can be formed from a hydrophilic material, such as a nylon, and/or the scraper can be spray coated, dip-coated, plasma etched, or otherwise  
 coated using various known coating techniques, with a 60 surfactant coating that renders the scraper or portions thereof hydrophilic. In an exemplary embodiment, where the scraper is formed from a hydrophobic material, such as a polyisoprene, a hydrophilic coating is applied to the scraper to render the scraper hydrophilic. The coating can be applied  
 to any one or more of the surfaces of the scraper, and it can 65 be applied at any stage during manufacturing. In one embodiment, the scraper can be soaked in a surfactant bath



during manufacturing to render the entire scraper hydrophilic. Exemplary coating materials include, by way of non-limiting example, Dodecylbenzene sodium sulfonate (SDBS), and Sodium Dodecyl Sulfate (SDS). The coating is preferably one that remains stable during sterilization, such as gamma and thermal sterilization.

A person skilled in the art will appreciate that various factors can be altered to facilitate the wicking action of the scraper. For example, the contact angle of a drop of fluid on a hydrophilic surface of the scraper can be optimized so that fluid will spread upon contact with the surface. In certain exemplary embodiments, the hydrophilic material can have a low contact angle, such as 90 degrees or less. Other factors that can affect the ability of the scraper to wick fluid away from the opening include the smoothness of the surface, the geometry of the wicking channels, and the surface tension of the fluid being applied. For example, the channel geometry can be designed so as to provide the capillary forces necessary to drive fluid to a minimum capillary height so that the fluid will extend just past the outer wall of the crown 420 to reach the sorbent 414. The channel geometry can be altered to achieve the desired capillary height. FIG. 30H illustrates one exemplary embodiment of a channel geometry that is optimized to facilitate the capillary action of the channel. As shown, the channel has a generally U-shaped cross-sectional shape, with the inner corners, located at the base of the channel, being rounded and having a radius of curvature  $r_1$ , and the outer corners, located at the opening of the channel, being rounded and have a radius of curvature  $r_2$ . The channel can also have a width  $w$  at the base, as measured between the opposed sidewalls of the channel, that differs from a width  $w_1$  at the opening, as measured between the outer rounded corners, and that also differs from a maximum width  $w_2$  as measured from the outer-most ends of the channel at the opening. The difference between width  $w$  and width  $w_1$  is indicated by reference  $x$ . The channel can further have a maximum height  $h$ , as measured from the base to the outer-most ends of the channel at the opening, that differs from a height  $h_1$ , as measured from the base to the outer rounded corners. The particular dimensions of the channel can vary. For example, the radius of curvature  $r_1$  at the base of the channel can be less than the radius of curvature  $r_2$  at the opening of the channel, and the width  $w$  at the base of the channel is less than the width  $w_1$  at the opening, which in turn is less than the maximum width  $w_2$  such that the width of the channel gradually increases from the base to the opening. In an exemplary embodiment, however, the width  $w$  at the base of the channel is preferably equal to or greater than the width  $w_1$  at the opening. The dimensions and cross-sectional shape of the channel can also vary along the entire length of the channel. For example, the channel can have a height and/or width that increases or decrease radially outward, such that the height and/or width of the channel near the central opening in the scraper is either less than or greater than the height and width of the channel near the outer perimeter of the scraper. Each channel can also reach a maximum height and/or width at a certain distance from the central opening, and the height and/or width can then remain constant along the remainder of the channel extending radially outward from that location. A person skilled in the art will appreciate that the channel can be modified to obtain a desired capillary height so as to cause fluid to be driven from the scraper opening, past the crown, and to the sorbent.

As indicated above, other modifications can be made to achieve an optimum wicking effect. In another embodiment, the scraper and sorbent can both be configured to have a

surface energy gradient, such that the surface energy increases as fluid travels from the opening in the scraper, along the channels, and into the sorbent.

The fluid remover 430 can also include a scraper crown 420, shown most clearly in FIG. 30F, that can extend distally from a distal surface of the scraper 422 and that can assist in mounting the scraper 422 and sorbent 414 within the housing. The scraper crown 420 can have various configurations, but in the illustrated embodiment it has a ring shaped body 434 with multiple pins 436 extending proximally therefrom. The pins 436 can extend through the corresponding holes 422 $h$  formed in the scraper 422 and into holes 418 $h$  formed in the lid 418, as shown in FIG. 30J. The crown 420 and lid 418 can be mated to one another using various techniques, such as a pressed fit or interference fit, adhesive or welding, etc. By engaging the scraper 422 between the lid 418 and the crown 420, the scraper 422 can have an outer diameter that is less than an inner diameter of the housing 402 such that a gap  $G$  is provided between the scraper 422 and the housing 402, as shown in FIG. 30D. The gap  $G$  will allow air to flow proximally past the scraper 422.

As further shown in FIG. 30F, the scraper crown 420 can also include a cut-out 426 formed in a sidewall thereof. One or more flange members 440 can extend radially outward from a sidewall of the scraper crown 420 on each side of the cut-out 426 formed through the crown 420 to define a pathway. The flange members 440 can be positioned to axially align with the a cut-out formed in the sorbent 414 and a cut-out formed in the lid 418, as will be discussed in more detail below, to form a complete pathway that allows the flow of insufflation gas from the insufflation port 406, through the cut-outs, and to the working channel 408 into the distal cannula 404. This allows insufflation to be delivered through the cannula while an instrument is passed through the fluid remover 430 and occludes the working channel. The flange portions 440 can be positioned on either side of an opening of the insufflation port 406, through which the insufflation gas flows. As a result, a pressure on each side of the fluid remover will be equalized.

The shaped scraper lid 418 is shown in more detail in FIGS. 30I and 30J, and it can have a generally circular or ring-shaped configuration that rests proximal to the scraper. In use, the lid 418 can serve to protect the proximal surface 432 of the scraper 422 from the insertion of sharp surgical instruments by acting as a guide or funnel for the surgical instrument into the opening 424 of the scraper 422. As indicated above, the scraper lid 418 can include one or more holes 418 $h$  formed in a distal surface thereof for receiving the pins 436 formed on the crown 420. The scraper lid 418 can also include an opening 418 $o$  through which a surgical instrument can extend that is in axial alignment with the opening 424 formed in the scraper 422, and a cut-out 448 formed in a sidewall or perimeter of the scraper lid 418 that aligns with the cut-out 446 formed in the scraper crown 420 and the sorbent 414.

As shown in FIG. 30J, in one embodiment the scraper lid 418 can further include a circular bead or compression ridge 450 protruding distally beyond a distal-most surface thereof such that the ridge extends toward and presses against the proximal surface of the scraper 422 to hold the scraper 422 in controlled compression between the compression ridge 450 on the lid 20 and the proximal surface of the crown 420. The compression ridge 450 can also function to seal off and prevent fluid from flowing back toward the opening of the scraper 422.

While there can be many configurations for the fluid remover 430, in the embodiment shown in FIGS. 30B-30E,



the fluid remover **430** also includes a sorbent **414** positioned circumferentially around the scraper crown **420** and configured to sorb fluid scraped by the scraper **422**. As shown in FIG. **30F**, the sorbent **414** can be configured to be positioned around the scraper crown **420**, and thus can have a cut-out **444** formed therein that aligns with the cut-out **426** formed in the crown **420**. The terminal ends of the sorbent **414** will thus abut the flange **440** on the crown **420**. As a result, the sorbent **414** will be substantially C-shape. The cut-out **444** in the sorbent **414** will also allow air to flow all the way around the outside of the scraper **422**, due to the gap **G** between the outer perimeter of the scraper **422** and the housing. The cut-out in the sorbent **414** will thus continue to allow air to pass by and around the scraper **422** in the event the sorbent **414** becomes clogged. This is particularly advantageous, as air forced to flow through the sorbent **414** could potentially push fluid out of the sorbent **414**. The sorbent **414** can be secured around the scraper crown **420** using any method known in the art including, for example, an adhesive or simply by an interference fit between an interior wall of the housing **402** and the scraper crown **420**. As will be appreciated by those skilled in the art, the sorbent **414** can have a solid ring shape, or any other shape, and it can be composed of multiple individual portions as needed.

While the sorbent **414** preferably has a shape that corresponds to the shape of the crown **420**, the sorbent **414** can be configured to be compressed between the crown **420**, the scraper **422**, and the housing **402**. Thus, the sorbent **414** can have an initial cross-sectional shape that is more square and it can deform into a shape that is more triangular. The sorbent **414** can be formed from various materials that allow it to be compressed, while still allowing the sorbent **414** to sorb fluid. The sorbent **414** can also be permeable such that air can flow therethrough.

The particular size of the sorbent **414** can also vary, but in an exemplary embodiment the sorbent **414** has an inner diameter that is greater than a diameter of the opening **424** in the scraper, such that the sorbent **414** will only contact the scraper **422** at a location radially outward of the opening **424**. This will allow fluid to flow from the opening, through the channels **422c**, and then sorbed by the sorbent. In an exemplary embodiment, the sorbent is positioned radially outward of the holes **422h** formed in the scraper, as this allows the sorbent **414** to be positioned around the crown **420**.

As indicated above, when the fluid remover **430** is fully assembled, it can rest within a distal portion of the proximal housing **402**. The sorbent **414** can be positioned in contact with an inner surface of the housing **402**, the crown **420** can be disposed within the sorbent **414**, the scraper **422** can rest on the crown **420** and be positioned in contact with the sorbent, and the lid can be positioned on the scraper **422** and be mated to the crown **420**. The lid **418** can optionally be sonic welded or otherwise fixedly mated to the housing **402** to secure the fluid remover **430** therein. As shown in FIG. **30F**, the sorbent **414** can include surface features, such as longitudinally extending grooves **415** formed on an inner surface thereof and configured to align with and receive the pins **436** on the scraper crown **420**.

When disposed within the housing **402**, the fluid remover **430** will be positioned in the path of insufflation. In particular, referring again to FIGS. **30C** and **30D**, the insufflation port **406** has a lumen **460** extending therethrough. The lumen **460** defines a longitudinal axis **LA** and has a cylindrical interior surface with a proximal-most interior surface **462** and a distal-most interior surface **464**. The fluid remover **430** is generally positioned in the pathway of the lumen **460**

and more particularly, it is positioned such that the proximal-most interior surface **462** of the lumen **460** is positioned distal to the scraper **422** and the longitudinal axis **LA** extends through a mid-portion of the sorbent **414**. In other words, the sorbent **414** is positioned in the path of the flow of gas from the insufflation port **406** to the distal cannula. A person skilled in the art will appreciate that the various components of the fluid remover **430** can be positioned at various locations relative to the insufflation port **406**. Since portions of the fluid remover **430** in the illustrated embodiment are positioned in the pathway of air flow from the insufflation port **406** to the distal cannula, the cut-outs **426** and **444** in the crown **420** and sorbent **414** will allow airflow to pass therethrough and into the distal cannula.

In use, a surgical instrument can be inserted through the seals **412**, **410** and through the opening **470** in the fluid remover **430** as needed in a particular procedure. Using the insufflation port **406**, insufflation gas can be introduced into the working channel **408** of the trocar **400** such that insufflation is achieved distal to the seals **412**, **410** and to the fluid remover **430**. The insufflation gas can travel along the pathway defined by the flange portions **440**, through the cut-outs **426**, **444** in the crown **420** and sorbent **414**, respectively, and into the working channel **408** of the distal cannula **404**. In this way, the fluid remover **430** can be distal to the seals **412**, **410** to remove fluid from instruments being withdrawn while allowing the flow of insufflation gas into the distal cannula. As a surgical instrument is withdrawn from the working channel **408**, fluid scraped from the surgical instrument by the scraper **422** flows radially outward and is sorbed by the sorbent **414**, thus keeping the fluid away from any instrument that may be reinserted into the working channel **408**. The fluid remover **430** thus allows for the removal of fluid from a surgical instrument at a position distal to the seals **412**, **410** while also allowing the introduction of insufflation gas distal to both the seals **412**, **410**. A person skilled in the art will appreciate the variations possible for the positioning of seals and fluid removers to allow insufflation distal to both.

FIG. **31** illustrates another embodiment of a lid **418'** for use with a fluid remover. In this embodiment, rather than including a cut-out **448** formed in a sidewall of the lid **418** for allowing air to pass by the lid **418** in a proximal direction toward the seals, the lid **418'** includes a plurality of holes or openings **448'** formed therein and positioned radially around a perimeter of the lid **418'**. The lid **418'** can include any number of holes at any location and having any size. The holes **448'** are merely configured to prevent the fluid remover from forming a seal, if not needed, as it may be desirable to maintain a zero pressure differential across the fluid remover in order to prevent air from forcing fluid out of the sorbent.

FIGS. **32A-32D** illustrate yet another embodiment of a trocar **500** having a fluid remover **530** disposed therein. As shown, the trocar **500** has a proximal housing **502** and a distal cannula **504** with a working channel **508** formed through and extending between proximal and distal ends thereof. As shown in FIG. **32B**, the housing **502** can include an instrument seal, such as a deep cone seal **512** (only a proximal rim is shown), positioned within a channel seal, such as a duckbill seal **510**. A person skilled in the art will appreciate that any number, type, and configuration of channel and/or instrument seals can be positioned within the housing **502**. The housing can also include an insufflation port **506** is formed in the housing **502** for providing an insufflation gas to the working channel **508**.



In this embodiment, the fluid remover **530** differs from fluid remover **430** described above in that it is positioned more distal relative to the insufflation port. In general, the fluid remover **530** has an opening **570** formed through a center portion thereof, in axial alignment with the working channel **508**, for receiving a surgical instrument. The opening **570** can be effective to remove fluid from a surgical instrument upon insertion and/or withdrawal therethrough. The fluid remover **530** is positioned distal to the seals **512**, **510** so that fluid can be removed from the surgical instrument before it is withdrawn through the seals **512**, **510** in order to prevent the deposit of fluid on the seals. As with fluid remover **430**, fluid remover **530** can have a configuration that allows the passage of insufflation gas from the port **506** to the distal cannula **504** even when an instrument is disposed through the fluid remover **530**. In particular, in this embodiment the fluid remover **530** is generally positioned in the pathway of the lumen **560** of the insufflation port **506** and more particularly, it is positioned such that the longitudinal axis **LA** of the lumen **560** extends through a substantially center portion of the scraper lid **518**. The proximal-most interior surface **562** of the port is thus generally aligned with a top wall **556** of the scraper lid **518**. As shown in FIG. 32B, the scraper **522** is thus positioned distal to the longitudinal axis **LA** of the lumen **560** and can generally be positioned in alignment with the distal-most interior surface **564** of the lumen **560**. In other embodiments, the scraper **522** can be positioned entirely distal or proximal to the distal-most interior surface **564** of the lumen **560**. A person skilled in the art will appreciate that the fluid remover **530** can be positioned in any number of ways relative to the lumen **560**.

Since portion of the lid **518** and the scraper **522** are positioned in the path of insufflation, the lid **518** and scraper **522** in this embodiment can each have a cut-out **548**, **546** that is positioned within the pathway of the insufflation gas to allow the gas to flow into the working channel **508**, as shown in FIG. 32D. The cut-outs **548**, **546** can align with the corresponding cut-outs **526**, **544** in the crown **520** and the sorbent **514**, respectively, similar to the crown **420** and sorbent **414** discussed above. As further shown in FIG. 32D, the scraper lid **518** can also include a rim or flange **550** extending around a proximal portion thereof and located proximal to the cut-out **548** formed in the sidewall of the scraper lid **518**. As a result, the notch **546** is not a complete cut-out, but is defined on three sides by two opposed notch side walls **552a**, **552b**, and a top wall **556** and thus the top wall **556** can optionally serve as a proximal, sealed boundary for the insufflation gas pathway that will be described below. In an exemplary embodiment, the top wall **556** can be positioned in alignment with the proximal-most interior surface **562** of the lumen **560** in the insufflation port.

Another exemplary embodiment of a trocar is illustrated in FIGS. 33A-39. As shown in FIG. 33A, a surgical access device or trocar **600** is provided. While the trocar **600** can have many configurations, it can generally include a housing **602** with a cannula **604** extending distally therefrom. The housing **602** and the cannula **604** can define a working channel **606** extending longitudinally through a center thereof for receiving a surgical instrument. An insufflation port **612** can be coupled to one side of the housing **602** for providing insufflation to the trocar **600**. In some embodiments, a fluid removal system which can include a scraper, a wicking element, and/or a sorbent, can be disposed within the housing **602**. While the insufflation port **612** can be disposed at many locations on the housing **602**, in this particular embodiment, the insufflation port **612** is posi-

tioned proximal to the fluid removal system and offset from the working channel **606** such that insufflation gas introduced into the housing by the insufflation port **612** passes distally through the fluid removal system to insufflate the cannula **604** and the body cavity when a surgical instrument is disposed within the working channel. A seal system can also be disposed within the housing **602** to prevent the escape of insufflation gas.

The trocar **600** is illustrated in more detail in FIG. 33B. In some embodiments the housing **602**, and optionally the cannula **604**, can be a single, integrally formed component, such as in some of the embodiments described above. In other embodiments, such as that illustrated in FIG. 33B, the housing **602** can include a proximal housing **608** and a separate distal housing **610** that couple together to form the housing **602**. The proximal housing **608** and the distal housing **610** can enclose the various components of the trocar **600**, such as the seal system and the fluid removal system. For example, the proximal and distal housings **608**, **610** can enclose a seal system that can generally include a zero-closure seal and an instrument seal, for example, a duckbill seal **616** and a deep-cone seal **618**, respectively. The seal system can further include an inner seal retainer **626** for holding and forming a seal with the various internal components, as will be described in more detail below.

The proximal and distal housings **608**, **610** can also enclose the fluid removal system, which can be disposed distal to the insufflation port **612**. As noted above, and as shown in FIGS. 33B and 38A, the fluid removal system can generally include a scraper **620** for scraping fluid from a surgical instrument inserted therethrough, a wicking element **622** disposed on the scraper (shown in FIG. 38A) for transferring scraped fluid away from the surgical instrument, and/or a sorbent **624** for retaining fluid away from the surgical instrument. Since the insufflation port **612** can be disposed within the housing **602** at a location proximal to the fluid removal system, in general, the fluid removal system can have an insufflation pathway formed therethrough, indicated by arrow **A** in FIG. 33B, to allow the passage of insufflation gas from a proximal portion of the trocar **600** to a distal portion thereof so that the area below the sealing system, including the cannula **604** and the body cavity, can be pressurized. The pathway can be offset from the working channel **606** so that insufflation gas can pass through the fluid removal system even when a surgical instrument is disposed within and occludes the working channel **606** of the trocar **600**. These and other aspects will be described in detail below.

The components of the housing **602** are illustrated in more detail in FIGS. 34A-35, and the proximal housing **608** is shown in detail in FIGS. 34A and 34B. The proximal housing **608** can generally be a substantially rigid, hollow component designed to enclose and retain the seal system and to receive the insufflation port **612** and stopcock **614**. The proximal housing **608** can have many configurations, but in the illustrated embodiment, it has a proximal endwall **632** with a sidewall **633** extending substantially orthogonally and distally therefrom. The proximal housing **608** can be generally open distally, without a distal endwall, to allow the distal end to mate to the distal housing. A cavity formed in the proximal housing can house the various inner components of the trocar **600** when the proximal housing **608** is combined with the distal housing **610**.

In some embodiments, the proximal endwall **632** can include an opening **628** for receiving a surgical instrument therethrough and for defining the working channel **606** extending along a central longitudinal axis of the trocar **600**.



A substantially rigid, cylindrical central lumen **630** can extend from the opening **628** a distance into the proximal housing **608** to define the working channel **606**. The central lumen **630** can also serve to guide a surgical instrument into the seal system. One or more mating elements **648** can be formed in the proximal endwall **632** of the proximal housing **608** for mating with an obturator for inserting the trocar **600** into tissue.

The proximal endwall **632** and the sidewall **633** of the proximal housing **608** can have an exterior surface **635** and an interior surface **634** that can have any shape as desired to provide the required interior space. The sidewall **633** can optionally include a bowed or distended portion **636** having an opening or cut-out **638** for receiving the insufflation port **612**. The sidewall **633** can also include a distal rim **641** that is configured to mate with a corresponding proximal rim **664** (shown in FIG. **35A**) of the distal housing **610**. The proximal rim **664** and the distal rim **641** can be mated together using any technique known in the art, including but not limited to, interference fit, press fit, adhesive, fastener, etc. For example, the proximal housing **608** can include one or more coupling members **640** for mating to the distal housing **610**. The illustrated embodiment includes four coupling members **640** each extending from a coupling lumen **642**. The lumens **642** can be integrally formed with and/or rigidly coupled to the interior surface **634** of the sidewall **633**, and the coupling members **640** can extend distally therefrom. The coupling members **640** can be substantially rigid, elongate pin-like components that are configured to be disposed within corresponding coupling lumens **666** (shown in FIG. **35A**) of the distal housing **610**. When the coupling members **640** are mated with the lumens **666**, a secure coupling can be formed between the proximal and distal housings **608**, **610** by way of, for example, an interference fit, a press fit, or an adhesive. A person having ordinary skill in the art will appreciate the variety of ways that the proximal and distal housings **608**, **610** can be mated together.

In one embodiment, each coupling lumen **642** can have a protrusion or rib **643** extending radially outward therefrom, as shown in FIG. **34B**. While the ribs **643** can have many configurations, in the illustrated embodiment, the ribs **643** are rectangular shaped protrusions that generally extend along a length of the coupling lumen **642**. Two of the ribs **643** located on one side of the cut-out **638** can be orientated toward one another and the other two ribs **643** located on the opposite side of the cut-out **638** can be oriented toward one another, as shown in FIG. **34B**. The ribs **643** can be configured to engage pads **693** formed on a flange **691** of the inner retainer **626** (shown in FIGS. **36** and **37A**). The ribs **643** can prevent the inner retainer **626** from floating within the proximal and distal housing **608**, **610** and can thereby ensure adequate compression of the seals **616**, **618** and the scraper **620** to maintain a pneumo seal. In particular, the ribs **643** can ensure that the gap between a proximal sealing flange **644** of the proximal housing **608** and a proximal retainer rim **680** of the retainer **626** is of an appropriate height to provide the desired compression of the seals **616**, **618** disposed within the gap. For example, when the proximal housing **608** is fully seated on and mated with the distal housing **610**, a distal end **637** of each rib **643** abuts and engages a corresponding pad **693** on the flange **691** of the inner retainer **626**. The distance between the distal end **637** of each rib **643** and the proximal sealing flange **644** of the proximal housing **608** can set the gap between the proximal sealing flange **644** and the proximal retainer rim **680** of the retainer **626** (described in more detail below). In this way, the amount of compression on the seals **616**, **618** seated

therebetween can be predicted. Similarly, the length of the ribs **643** can also set the gap between the inner retainer **626** and the distal housing **610**, thus controlling the amount of compression of the scraper **620**, also described in more detail below.

The proximal housing **608** can also include features for retaining and sealing against the seals **616**, **618**. For example, in some embodiments, the proximal housing **608** can include a proximal sealing flange **644** formed on an interior surface **646** of the proximal endwall **632**, as shown in FIG. **34B**. The proximal sealing flange **644** can be a substantially rigid cylindrical member having a diameter greater than a diameter of the central lumen **630**, but less than a width of the proximal housing **608**. In general, the proximal sealing flange **644** can act with the seal retainer **626** to retain and form a seal with the duckbill seal **616** and the deep-cone seal **618**, as will be described in detail below.

The distal housing **610** can also have many configurations and one embodiment is shown in more detail in FIGS. **35A** and **35B**. Similar to the proximal housing **608**, the distal housing **610** can generally be a substantially rigid, hollow component designed to enclose and retain the fluid removal system and to receive the insufflation port **612**. The distal housing **610** can have many configurations, but in the illustrated embodiment it has a distal endwall **652** with a sidewall **654** extending substantially orthogonally and proximally therefrom. The distal housing **610** can be generally open proximally, without a proximal endwall, and the sidewall **654** can define a cavity made for housing the various inner components of the trocar **600** when the distal housing **610** is combined with the proximal housing **608**.

The distal housing **610** can also generally be configured for receiving a surgical instrument therethrough and it can be configured to mate with the insufflation port **612** and the proximal housing **608**. For example, the distal housing **610** can include an opening **650** formed in its distal endwall **652** for receiving a surgical instrument therethrough and for defining the working channel **606** extending into the cannula **604**. In some embodiments, the distal endwall **652** and the sidewall **654** can have an exterior surface **656** and an interior surface **658** and can have any shape as desired that provides the required interior space. The sidewall **654** can optionally include a bowed or distended portion **660** that includes an opening or cut-out **662** for receiving the insufflation port **612**. The sidewall **654** can also include a proximal rim **664** that is configured to mate with a corresponding distal rim **641** (shown in FIG. **34B**) of the proximal housing **608**. The proximal rim **664** and the distal rim **641** can be mated together using any technique known in the art, including but not limited to, interference fit, press fit, adhesive, fastener, etc. For example, the distal housing **610** can include one or more coupling lumens **666** for mating to the proximal housing **608**. The illustrated embodiment includes four coupling lumens **666** each integrally formed with and/or rigidly coupled to the interior surface **658** of the sidewall **656**. The coupling lumens **666** can be substantially rigid, hollow components that are configured to receive corresponding coupling members **640** (shown in FIG. **34B**) of the proximal housing **608** to securely mate the proximal and distal housings **608**, **610** together as described above.

The distal housing **610** can also include features for retaining and sealing against the scraper **620**. For this purpose, the distal housing **610** can include a distal sealing flange **668** formed on the distal endwall **652**. The distal sealing flange **668** can be a substantially rigid cylindrical member having a diameter greater than a diameter of the opening **650**, but less than a width of the distal housing **610**.



In general, the distal sealing flange **668** can act with the seal retainer **626** to retain and form a seal with the fluid removal system, as will be described in detail below. In addition, the distal housing **610** can include a plurality of ridges **651** that are designed to seat and mate with the scraper **620** as will be described in detail below. The ridges **651** can be formed integrally with a proximal surface of a wall **736** extending from the floor of the distal housing **610**, and can have high and low portions that define each ridge **651**.

A cavity **670**, shown in FIG. **35A**, can be formed between the opening **650** and the distal sealing flange **668** for seating the sorbent **624**. The cavity can have one or more ridges, for example, a plurality of ridges **672** formed around an interior surface of the distal sealing flange **668** for providing frictional engagement with the sorbent **624**. The cavity **670** can also include a plurality of features, for example, four nubs **671** that extend proximally from the floor of the cavity **670** and that are designed to engage the sorbent **624** and press the sorbent **624** into engagement with the scraper **620** as will also be described in more detail below. As will be appreciated by those skilled in the art, any sort of feature sufficient to press the sorbent **624** into engagement with the scraper **620** can be used within the cavity **670**. The nubs **671** can be formed integrally with the distal housing **610** or can be coupled thereto by an adhesive or other fixation mechanism.

The distal housing **610** can optionally be integrally formed with the cannula **604**. The cannula **604** can extend distally from the distal housing **610** and can terminate distally in an angled portion that forms a distal piercing tip **605** that facilitates entry through tissue into a body cavity. In some embodiments, a longest point of the angled distal tip **605** of the cannula **604** can be oriented relative to the distal housing **610** such that it is aligned with the insufflation port **612**, although it can have any orientation desired. The distal housing **610** can also have one or more suture loops or other suture tie down features **675** formed around an outer perimeter of an exterior surface **656** thereof. Each suture tie down feature **675** can define an opening or pathway formed therethrough for receiving suture to help better secure the trocar **600** when it is disposed in tissue. The suture tie down feature **675**, shown in FIG. **33A**, can have any angular orientation relative to the angled distal tip **605** of the cannula **604**, but in one embodiment, at least one tie down feature **675** is offset by 90 degrees from the longest point of the angled distal piercing tip **605**. In other embodiments, the suture tie down feature **675** can be positioned in line with the angled distal tip **605** of the cannula **604**, or offset by 180 degrees therefrom.

While the seal system and fluid removal system disposed within the housing **602** can have many different configurations, one exemplary embodiment of these systems is shown in more detail in FIG. **36**. As noted above, the illustrated seal system includes a duckbill type channel seal **616**, a deep-cone type instrument seal **618**, and an inner seal retainer **626** for securing the sealing elements within the trocar **600**. As will be appreciated by those having ordinary skill in the art, any suitable sealing combination can be utilized within the housing **602** that is effective to maintain insufflation of the cannula **604** and the body cavity during use. Thus, the sealing combination can generally include both a zero-closure seal and an instrument seal and/or a single seal that is capable of both zero-closure and sealing around an instrument. In the illustrated embodiment, the deep-cone seal **618** is disposed within the duckbill seal **616** such that an instrument inserted into the working channel **606** through the opening **628** in the proximal housing **608** will encounter the deep-cone seal **618** first. Since it is positioned proximal

to the duckbill seal **616**, the deep-cone seal **618** will form a seal around the surgical instrument before the surgical instrument encounters and opens the duckbill seal **616**. In this way, insufflation can be maintained during insertion of the instrument into the trocar **600**.

While there are various ways to retain the seals within the housing **602**, in the illustrated embodiment, the seals **616**, **618** are disposed within and coupled to the seal retainer **626**. The seal retainer **626** and the proximal and distal housings **608**, **610** can generally function together to seal the working channel **606** by pressing and sealing against a perimeter of the seals **616**, **618**. In particular, as shown in FIGS. **36-37B**, the seal retainer **626** can be a substantially rigid cylindrical component that defines a portion of the working channel **606** and seals the working channel **606** from a region in the housing **602** outside of and/or surrounding the retainer **626**. The seal retainer **626** fits within the housing **602** and that can have a proximal end **706** and a distal end **702**. The proximal end **706** can have an opening **700** that is substantially the same diameter as an outer diameter of the retainer **626**, although it can have any diameter as necessary to accommodate the seals **616**, **618**. The distal end **702** can include a distal endwall **708** with an opening **704** extending therethrough. The opening **704** can have any diameter as needed, for example, a diameter that is smaller than the outer diameter of the retainer **626**, but at least large enough to receive a surgical instrument. The retainer **626** can have a sidewall **711** extending between its proximal and distal ends **706**, **702**. In some embodiments, the distal endwall **708** can include a plurality of ribs **707** extending radially from the opening **706**, as shown in FIG. **37C**. The ribs **707** can be configured for maintaining positive contact between the scraper **620** and the sorbent **624**.

As noted above, in some embodiments the seals **616**, **618** can be retained by and sealed between the seal retainer **626** and the sealing flange **644** of the proximal housing **608**. In particular, the retainer **626** can have a proximal retainer rim **680** that can engage a distal surface **682** of a flange **684** formed on the duckbill seal **616**. The proximal sealing flange **644** of the proximal housing **608** can engage the proximal surface **686** of the flange **688** on the deep-cone seal **618**. As shown most clearly in FIG. **33B**, when the trocar **600** is assembled, the proximal retainer rim **680** and the proximal sealing flange **644** compress together around the outer perimeter of the flanges **684**, **688** and form a seal thereagainst such that the working channel **606** is sealed for the purposes of insufflation. As well, the proximal rim **680** and the sealing flange **644** can retain the seals **616**, **618** within the housing **602**. As noted above, the amount of spacing between the distal end **637** of the ribs **643** in the proximal housing **608** and the proximal sealing flange **644** of the proximal housing **608** can be used, at least in part, to predict and control the amount of compression of the seals **616**, **618**.

As also noted above, at least a portion of the fluid removal system can be retained by and sealed between the seal retainer **626** and the sealing flange **668** of the distal housing **610**. In particular, the seal retainer **626** can include a distal retainer rim **690** that can engage a proximal surface **692** of the scraper **620**. In addition, the distal sealing flange **668** in the distal housing **610** can engage a distal surface **694** of the scraper **620**. When the trocar **600** is assembled, the distal retainer rim **690** and the distal sealing flange **668** compress together around the outer perimeter of the scraper **620** to form a seal thereagainst such that the working channel **606** is sealed for the purposes of insufflation. As well, the distal rim **690** and the sealing flange **668** can retain the scraper **620** within the housing **602**.



As shown in FIGS. 33B, 36, and 37A the seal retainer 626 can further include a median flange 691 extending radially outward from the retainer 626 and disposed around an outer circumference thereof. The median flange 691 can generally be disposed anywhere along a length of the retainer 626, but in the illustrated embodiment it is disposed near a mid-portion of the retainer 626. The median flange 691 can be configured to engage an inner sidewall of the proximal and distal housings 608, 610 at a point where the proximal and distal housings 608, 610 mate together. In this way, the retainer 626 can be retained and secured within the housing 602. As noted above, the flange 691 can also include a plurality of pads 693 configured to engage ribs 643 in the proximal housing 608. The length of the ribs 643 can be used to predict and control the compression of the seals 616, 618 and the scraper 620. In some embodiments, the median flange 691 can have a portion 710 that curves or dips distally to accommodate the structure of the proximal and distal housings 608, 610 near the coupling point for the insufflation port 612.

In some embodiments, the seal retainer 626 can also include a port 696 for receiving the insufflation port 612. An opening 706 can be formed in a distal endwall 708 of the retainer 626 to allow insufflation gas to flow from the port 696 and through the distal endwall 708 to insufflate the cannula 604 and the body cavity.

As noted above, the trocar 600 can include a fluid removal system generally configured to remove fluid from a surgical instrument and transfer and store the fluid at a location away from the working channel 606 and any surgical instrument inserted therethrough. The fluid removal system can have many configurations, but as shown in FIG. 36, and as noted above, it can include the scraper 620 having the wicking element 622 formed thereon (shown in FIG. 38A) and the sorbent 624 positioned adjacent to the scraper 620 to sorb fluids wicked by the wicking element 622.

The scraper 620 is shown in more detail in FIGS. 38A-38C and can have any of the same or similar features and configurations previously described. The scraper 620 can be a substantially circular component having a proximal surface 722 and a distal surface 694. An opening 712 can be formed through a center of the scraper 620 for receiving a surgical instrument therethrough. The opening 712 can have a diameter substantially the same as, or slightly smaller than, a diameter of a surgical instrument inserted therethrough so that the opening 712 scrapes along the outside of a surgical instrument as it is passed therethrough to remove fluid therefrom. As noted in the previous embodiments, the scraper 620 can be formed of a flexible material and can therefore invert proximally as a surgical instrument is being withdrawn through and scraped by the opening 712.

There are many ways in which the scraper 620 can be retained within the housing 602. As noted above, in one embodiment the scraper 620 can be retained by and disposed between the distal retainer rim 690 of the retainer 626 and the distal sealing flange 668 of the distal housing 610. Because the scraper 620 can be formed of a flexible and/or compressible material, as the rim 690 and the flange 668 engage the outer perimeter of the scraper 620, the outer perimeter of the scraper 620 can be compressed therebetween and a seal can be formed between the scraper 620, the rim 690, and the flange 668. As noted above, the amount of spacing between the distal end 637 of the ribs 643 in the proximal housing 608 and distal retainer rim 690 can be used, at least in part, to predict and control the amount of compression of the scraper 620. The outer perimeter of the scraper can optionally include a lip 724 extending prox-

mally from the proximal surface 722. The rim 690 and the flange 668 can compress the scraper 620 at a location radially inward of the lip 722, as can be seen in FIG. 33B.

In some embodiments, the scraper 620 can include features to assist in securing the scraper 620 within the housing 602. For example, the outer-most perimeter of the scraper 620 can include one or more indentations, for example, four indentations 714 for receiving protrusions 716 in the distal housing 610. The protrusions 716 are coupled to and/or integrally formed with the lumens 666 and serve to further stabilize the scraper 620 within the distal housing 610. The scraper 620 can also include an opening or hole 718 that can align with the opening 706 formed in the retainer 626 to allow insufflation gas to flow therethrough. The hole 718 can have any size or shape known in the art that is sufficient to allow the flow of insufflation gas therethrough. In the illustrated embodiment, the hole 718 is substantially rectangular and of a size to match the opening 706. The hole 718 can be offset from the opening 712 such that an axis extending through the center of the hole 718 that is parallel with the longitudinal axis of the trocar 600 is offset a distance away from the longitudinal axis of the trocar 600.

As noted above, the scraper 620 can also include features formed thereon, such as the wicking element 622, for wicking fluid away from the working channel 606. While the wicking element 622 can take any form suitable to wick fluid away from the opening 712, in the illustrated embodiment, the wicking element 622 can be one or more channels 720 formed in the distal surface 694. The channels 720 can extend partially into the distal surface 694 of the scraper 620 and can have a depth suitable to contain and transfer fluid away from the opening 712. The channels 720 can begin at the opening 712 and extend radially outward therefrom, or they can begin a radial distance away from the opening 712 and extend radially outward therefrom, as shown in FIGS. 38A and 38C. Similarly, the channels 720 can extend all the way to the outer-most circumference of the scraper 620, or they can stop a distance away from the outer-most circumference, as shown in FIG. 38A. A person skilled in the art will appreciate the variety of configuration possible for the channels 720.

There can also be any number of channels 720 formed in the scraper 620 as desired and they can be arranged around the scraper 620 with even spacing therebetween and/or with uneven spacing therebetween. In the illustrated embodiment, a plurality of channels 720 are formed in the scraper 620 and the majority thereof are generally spaced evenly around the scraper 620. However, channels 720 near the hole 718 can differ in spacing. For example, four of the channels 720 near the hole 718 are not spaced evenly with the other channels 720. Instead two channels 720 on one side of the hole 718 and two channels 720 on the other side of the hole 718 are spaced closer together to provide room for the hole 718 and to ensure that fluid is directed away from the hole 718. As noted above, the scraper 620 can be seated on the ridges 621 formed on the wall 736 of the distal housing 610. In particular, the ridges 621 can engage a narrow circumference of the scraper 620 that is closer to the center opening 712 than to the outer-most circumference, for example about one-quarter to one-third of the way along a length of the channels 720, although any configuration is possible. This narrow circumference of engagement allows the scraper 620 to be seated within the distal housing 610 without causing the channels 720 to buckle or collapse, as would likely happen with a wider area of engagement. The channels 720 can be aligned with the ridges 621, as illustrated in FIG. 38C, such that each channel 720 is aligned with a low



portion or valley of the ridges 621 to ensure fluid flow through the channel 720. Each high portion or peak of the ridges 621 extends proximally between the channels 720. The channels 720 can be adjacent to and in contact with the sorbent 624 to wick fluid to the sorbent 624.

The sorbent 624 can also have many shapes and configurations, as noted in detail above. In the embodiments illustrated in FIGS. 36 and 39, the sorbent 624 can be substantially c-shaped and/or substantially circular shaped with a cut-out 730 in one side. A center opening 727 of the sorbent 624 can have a diameter that is greater than a diameter of the working channel 606 of the cannula 604 and/or of the opening 712 formed in the scraper 620. The sorbent 624 can have a proximal surface 726 and a distal surface 728, as well as an outer surface 732 and an inner surface 734. The sorbent 624 can generally have a rectangular cross-section with a width W and a height H, and in some embodiments, the width W can be less than a height H. In other embodiments, the sorbent 624 can have a circular cross-section, a triangular cross-section, etc. The sorbent 624 can generally have a size suitable to be positioned within the cavity 670 formed within the distal housing 610. The cut-out 730 can have any width and configuration, and in the illustrated embodiment it has a width similar to but larger than the size of the hole 718 in the scraper 620 and the opening 706 in the retainer 626. For example, the cut-out 730 can have a width larger than parallel walls 677 within the distal housing 610 defining an insufflation pathway 674 through the distal housing 610. The hole 718 in the scraper 620 and the opening 706 in the retainer 626 can have a width substantially the same as the width of the walls 677 in the distal housing 610. The larger width of the cut-out 730 compared with the width of the hole 718 and the opening 706 is to ensure that the insufflation pathway remains clear of any fluid retained in the sorbent 624. In use, the cut-out 730 is preferably aligned with the hole 718 and the opening 706.

As noted above, the sorbent 624 can be seated within the cavity 670 and on top of the nubs 671. The nubs 671 can engage the distal surface 728 of the sorbent 624 and can elevate the sorbent 624 to bias the sorbent 624 into engagement with the scraper 620. In particular, the proximal surface 726 of the sorbent 624 can be pressed into engagement with the distal surface 694 of the scraper 620. In some embodiments there can be a compression force that results in an interference contact between the surfaces 726, 694 in the range of about  $\frac{1}{1000}$  to about  $\frac{18}{1000}$  inches to ensure sufficient contact between the two surfaces 726, 694 without blocking the channels 720 and preventing fluid transfer. The engagement between the two surfaces 726, 694 provided by the nubs 671 results in efficient transfer of fluid from the channels 720 of the wicking element 622 to the sorbent 624. Fluid scraped by the opening 712 can travel radially outward from the opening 712 through the channels 720, past the ridges 621, and into contact with the sorbent 624 to be sorbed thereby.

When the trocar is assembled, all of the holes, openings, and pathways through the various components of the fluid removal system can be aligned to form an insufflation pathway through the fluid removal system, as shown by arrow A in FIG. 33B. More particularly, the sorbent 624 can be positioned within the cavity 670 within the distal housing 610. Ridges 672 can engage the outer surface 732 of the sorbent 624, while the inner surface 734 engages a wall 736 defining the opening 650 that extends into the cannula 604. Opposed sides 738a, 738b of the cut-out 730 can be positioned on either side of the channel or pathway 674 extending from the opening 650 within the distal housing 610. The

pathway 674 can be aligned with the port 696 of the retainer 626 to allow the insufflation gas to flow therethrough. The scraper 620 can be positioned on top of or proximal to the sorbent 624 such that the outer perimeter of the scraper 620 rests on the distal sealing flange 668 of the distal housing 610, and such that the wicking element 622 is adjacent to and in contact with the sorbent 624. In this way, fluid scraped by the scraper 620 will be wicked along the channels 720 and sorbed by the sorbent 624. The sorbent 624 will hold the fluid away from the working channel 606, and thus away from any instruments inserted through the working channel 606. The hole 718 in the scraper 620 can be aligned with the pathway 674 in the distal housing 610 and with the cut-out 730 in the sorbent 624 to allow the flow of insufflation gas therethrough.

Further, the seal retainer 626 can be positioned proximal to the scraper 620 such that the distal rim 690 is positioned on the proximal surface in contact with the outer perimeter of the scraper 620 and forms a seal thereagainst with the distal sealing flange 668. The opening 706 in the retainer 626 can also be aligned with the hole 718 in the scraper 620, the cut-out 730 in the sorbent 624, and the pathway 674 in the distal housing 610 to form the insufflation pathway to allow the flow of insufflation gas therethrough. In this way, insufflation gas from the port 696 passes from an area in the distal housing 610 that is proximal to the fluid removal system through the pathway created by the opening 706, the hole 718, the cut-out 730, and the pathway 674 and into an area distal to the fluid removal system. The insufflation gas can therefore pass into the cannula 604 and into the body cavity through the fluid removal system even when a surgical instrument occludes the opening 712 in the scraper 620.

In use, once the trocar 600 is inserted into a body cavity, the insufflation port 612 can be used to introduce insufflation gas into the housing 602 through the port 696 in the seal retainer 626. In other embodiments, insufflation gas can be introduced into the housing 602 before an instrument is inserted therethrough. The gas can flow into the channel 740 in the retainer 626 near the distal end of the duckbill seal 616 shown in FIG. 33B, and into the insufflation pathway created through the fluid removal system as described above, as well as through the working channel 606. When an instrument is disposed through the trocar 600, the deep-cone seal 618 forms a seal around the instrument to maintain insufflation distal of the seal 618. Further, the surgical instrument occludes the opening 712 in the scraper 620, preventing the flow of gas through the working channel 606. The insufflation pathway that extends through the fluid removal system is offset from the working channel 606, and thus insufflation gas can flow through the insufflation pathway in the direction of arrow A, shown in FIG. 33B, as described above.

As a surgical instrument is withdrawn from the trocar 600, it is pulled through the opening 712 in the scraper 620. The opening 712 can scrape fluid from the outside of the surgical instrument. The fluid can travel into the wicking channels 720 and be wicked away from the opening 712. The channels 720 can transfer the fluid to the sorbent 624, where it is held away from the opening 712 so that any subsequently inserted surgical instruments will not be contaminated by fluid. It will be appreciated by those having ordinary skill in the art that the order of use and/or method steps is not important and thus can be performed in any order.

In another embodiment, all of the above described fluid remover embodiments can be formed into a single "drop-in" unit as needed. The drop-in unit can include sorbent elements, scraper elements, wicking elements, and/or combinations thereof. These elements can be combined as needed



into an externally configured unit that can be placed into an existing trocar system as needed. Thus, the drop-in unit will fit in and around any seals and components disposed within the proximal housing, including the removable cap, and/or within the cannula. For example, the drop-in unit can be configured to fit below or distal to one or more sealing elements and/or it can be configured to fit above or proximal to one or more sealing elements. Alternatively or in addition, the drop-in unit can be configured to have components that fit above, below, or in between sealing elements. The drop-in unit can also include the seals therein such that the entire unit can be placed into an empty housing of a trocar. The drop-in unit can also be removable as needed, and the unit, or portions thereof, can be reusable.

Methods for removing fluid from a surgical instrument are also generally provided. In an exemplary embodiment, a surgical instrument can be passed through an access device and a fluid remover in the access device can remove any fluid on the instrument, or fluid deposited on a seal within the access device by the instrument. In one exemplary embodiment, a fluid remover can engage a surgical instrument passed through an access device, such as a trocar, upon removal of the instrument to thereby remove fluid from the instrument, thus preventing the fluid from accumulating on the seal(s) and/or from being redeposited on instruments passing therethrough. As indicated above, the fluid remover can be formed from any combination of one or more sorbing, scraping, and wicking elements. A person skilled in the art will appreciate that virtually any combination of sorbing, scraping, and wicking elements can form the fluid remover resulting in a variety of methods for removing fluid that can include any combination of sorbing, scraping, and wicking fluid away from a surgical instrument and/or from a seal or other portion of a trocar or other access device.

A person skilled in the art will appreciate that the present invention has application in conventional endoscopic and open surgical instrumentation as well application in robotic-assisted surgery.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. By way of non-limiting example, the scraper and/or sorbent can be removed, cleaned, re-coated with a hydrophilic material, sterilized, and reused. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Preferably, the devices described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and its contents are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation

kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

It is preferred that device is sterilized. This can be done by any number of ways known to those skilled in the art including beta or gamma radiation, ethylene oxide, steam.

One skilled in the art will appreciate further features and advantages of the invention based on the above-described embodiments. Accordingly, the invention is not to be limited by what has been particularly shown and described, except as indicated by the appended claims. All publications and references cited herein are expressly incorporated herein by reference in their entirety.

What is claimed is:

1. A surgical access device, comprising:

a proximal housing, a distal cannula, and a working channel extending through the proximal housing and the distal cannula that is sized and configured to receive a surgical instrument;

a seal disposed within the proximal housing configured to seal the working channel when no surgical instrument is disposed therethrough, the seal having an opening extending therethrough and positioned to receive a surgical instrument passed through the working channel; and

a fluid remover positioned distal of the seal, the fluid remover having an opening extending therethrough and positioned to receive a surgical instrument passed through the working channel, and the fluid remover being configured such that, when an instrument occludes the opening in the fluid remover, the fluid remover allows insufflation gas to pass between a proximal side of the fluid remover and the distal cannula to thereby equalize a pressure on proximal and distal sides of the fluid remover.

2. The surgical access device of claim 1, wherein the fluid remover is positioned such that it is configured to be in a pathway of an insufflation gas flowing from an insufflation port formed in the proximal housing.

3. The surgical access device of claim 1, wherein the fluid remover includes a cut-out formed in at least a portion thereof and configured to allow an insufflation gas to pass from an insufflation port, through the cut-out, and into the distal cannula when an instrument occludes the opening.

4. The surgical access device of claim 1, wherein the fluid remover includes a scraper configured to scrape fluid off of a surgical instrument passed through the opening.

5. The surgical access device of claim 4, wherein the fluid remover includes a sorbent positioned to sorb fluid removed by the scraper.

6. The surgical access device of claim 5, wherein the sorbent is positioned distal to an insufflation port.

7. The surgical access device of claim 5, wherein the sorbent is disposed around a substantially cylindrical member.

8. The surgical access device of claim 4, wherein an insufflation port has a lumen extending therethrough and defining a longitudinal axis, and wherein the scraper is positioned distal to the longitudinal axis.

9. The surgical access device of claim 1, wherein at least a portion of the fluid remover is positioned distal to an insufflation port.

10. A surgical access device, comprising:

a housing defining a working channel sized and configured to receive a surgical instrument;



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a seal disposed within the housing, the seal having an opening positioned to receive a surgical instrument passed through the working channel;

a sorbent disposed in the housing and configured to sorb fluid to prevent fluid from being redeposited on surgical instruments passed through the working channel; and  
 a scraper disposed in the housing and configured to scrape fluid off of surgical instruments passed through the working channel, the scraper being in contact with a proximal surface of the sorbent.

11. The surgical access device of claim 10, wherein the sorbent is positioned to sorb fluid away from the opening in the seal.

12. The surgical access device of claim 10, wherein the sorbent comprises an absorbent.

13. The surgical access device of claim 10, wherein the sorbent comprises an adsorbent.

14. The surgical access device of claim 10, wherein the housing includes a proximal portion containing the seal and a distal cannula extending distally from the proximal portion and configured to be inserted into a body cavity.

15. The surgical access device of claim 14, wherein the seal comprises a first seal, and the access device further comprises a second seal disposed within the housing, and wherein the sorbent is positioned distal of the first and second seals.

16. The surgical access device of claim 10, wherein the sorbent is configured to sorb fluid scraped by the scraper.

17. The surgical access device of claim 10, further comprising a wicking element disposed in the housing and configured to wick fluid away from a surgical instrument passing through the working channel.

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18. An assembly for use in a surgical access device, comprising:

a seal having an opening configured to receive a surgical instrument therethrough;

a sorbent associated with the seal and configured to sorb fluid away from at least one of the opening and a surgical instrument passed through the opening; and

a scraper element configured to scrape fluid off of a surgical instrument extending through the opening of the seal, the scraper element being in contact with a proximal surface of the sorbent.

19. The assembly of claim 18, wherein the sorbent is an adsorbent element.

20. The assembly of claim 18, wherein the sorbent is an absorbent element.

21. The assembly of claim 18, wherein at least a portion of the scraper element is hydrophilic.

22. The assembly of claim 18, further comprising a wicking element associated with the scraper and configured to wick away fluid collected near the opening of the seal when a surgical instrument is passed through the opening.

23. The assembly of claim 18, further comprising a wicking element associated with the seal and configured to wick away fluid collected near the opening when a surgical instrument is passed through the opening.

24. The assembly of claim 18, wherein the seal comprises an instrument seal configured to form a seal when an instrument is inserted therethrough.

25. The assembly of claim 18, wherein the seal comprises a first seal, and the assembly further comprises a second seal.

26. The assembly of claim 25, wherein the sorbent is positioned distal of the first and second seals.

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